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TIMEWASTERS

Every once in a while, in our pursuit of more and better *Timewasters*, we run into some low grade activity along this line. For instance, here is what we picked up at a church supper the other night: "A man is in a concrete dungeon that is a first class dungeon; the only tool he has is a baseball bat. How does he get out?" And, "You come home to find all floors and windows locked, and your keys have been left in the office. How do you get into your home?" Well, we thought we were making an error in going to that dinner. Answers will be found somewhere in the last four or five pages of this issue, unless we forget to put them there.

But here is a better one. You have three sevens to play with—7, 7, 7—no more, no less. You can add, subtract, multiply or divide, or do all of them; but your answer should be 20. How do you combine these to equal the said 20?

Solutions:

Mr. Blunk says, regarding the surveyor problem in the January issue, that the best way to solve this is by putting a tack in the ground, then planting a tree over the tack and waiting for it to grow before locating the corners of the lot. However, he was in a hurry and didn't choose to wait that long, so he plantd a tree, and found the lot was 57 ft. square, and the area 3,249 sq. ft. There may be a fraction of a foot variation, he says, in this cold weather, but that is about the answer.

The bicycle problem was easy. There were 13½ miles of level going, 9 miles up and 4½ miles down.

The Finisher-Up:

Walter Wheeler, from up in New Hampshire, who no doubt has been snowed in and frozen up of late, hands us a neat little problem that should keep our surveyor-members engaged for a few minutes. "With a transit measuring degrees only—no minutes, no seconds—and a tape measuring feet only—no fractions—lay out equal adjacent chords along 90° of a simple curve. The last digit is 9 in each of the numbers representing the number of chords, length of each chord and length of radius. What are they?"

What queer tools they work with up there in the frozen north. *W. A. H.*

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A. M. Williams

Get the Most Out of Your Gravel Roads

By A. M. WILLIAMS

County Engineer, Ionia Co., Michigan

During 1937 four states used gravel almost exclusively for new construction, and the total mileage laid that year was exceeded only by low-cost bituminous mix. So practical suggestions, such as Mr. Williams gives for maintaining gravel roads, should be welcomed by a large percentage of our highway engineers.

GRAVEL has been, and will continue to serve as, a valuable road material, although it has two major objections—dust and the continual need of scraping. Dust control demands a definite amount of money, if dust is to be eliminated; but scraping, on the other hand, can be reduced if certain characteristics of gravel are recognized.

It will be a long time before all gravel roads will be replaced with something different, so we have to do the best we can with them. A gravel surface that approaches a pavement is the ideal for which we are striving. It can be accomplished only by careful procedure in the proper use of the materials and equipment.

Road gravel is best when it is well graded and packs within a reasonable time. If it contains too much clay or binding material it will pack quickly, but also will cut or rut quickly when wet, so it is necessary to have the correct make up of the gravel if we are to obtain a stable surface.

If the fines do not have the necessary cement to bind themselves tightly together, clay is generally added. (Other materials would give the same effect, but their cost would generally be prohibitive.) Clay is a fine natural soil, and when dry possesses a cementing property much desired in a road. But the clay becomes softened when contacted with water for any length of time. Its bond, when dry, is not as strong as that of portland cement, and therefore is subject to faster wear under the wheels of traffic. When broken loose from the road surface, clay readily blows away and is lost forever and the road begins to ravel. Clay, being the finest of the fines that make up the surface, leaves the road first. Then the next size particles loosen and float around, acting as an abrasive or cutting medium between the tires and road, and wear the surface even more quickly than before. This process goes on until considerable loose material of all sizes has left the compacted road surface and sets up a more rapid deterioration. *This is the reason loose material should not be allowed to remained on the traveled portion of the road for long, nor should it be scraped on and allowed to remain.* You will note that where loose material is on a road it is more dusty than one that is bare. *If you haven't already noticed this, look for it because it proves this point—that loose material hastens wear.* Again, to demonstrate the wear created by loose gravel, notice the concrete pavements where gravel roads connect. You will find them pitted and roughened. Such wear goes on much faster on a gravel surface than on concrete. A gravel road, therefore, is its own worst enemy. *You can prevent much of this wear by keeping the loose material off the traveled track.*

Theory of Maintenance

When gravel that contains clay or other binders becomes wet, it forms a mortar similar to cement mortar, in that if either is disturbed when setting, the bond is destroyed and it will not knit together again. In either case they have to be remixed, and this can only be done when wet. *So it is important that you do not scrape a road after it has started to set.* Get it shaped and leave it while it is still in the plastic stage and allow traffic to roll it out. You will find that much of the former loose material has become tied down.

Material that has become loosened and collected on the side of the road has lost all cementing qualities and will not recombine with the road until sufficient binder has been replaced. There is no use in scraping this mate-

rial over the road surface even when wet, as it will not stick and you can't make it. To do so only makes a bad condition worse. You have thrown a lot of loose stone onto the road to only create more by tearing away that part of the road that still remained intact. *Loose material* on the surface is the enemy of a gravel road. *Remember this, for it cannot be emphasized too strongly. We don't want it.*

Washboards or Chatterbumps

Washboard or chatterbumps are caused by the wheels of cars or trucks rising out of contact with the road, when they pick up speed, and as they return to the road tend to kick out a little material. Successive vehicles do the same and it isn't long before a series of bumps have formed. A few irregularities in the road start them, and after being started they continue to enlarge if allowed to remain. The hollows developed cannot be filled to eliminate the bumps; when filled with dry, loose material it soon whips out and you again have the bumps and a lot of objectionable loose gravel rolling around. The only remedy is to cut the tops off the bumps, and the time to do this is during a rain, when the surface is softened. Sometimes the road surface is so stony it can't be cut with a blade and must be scarified.

Scraping Loose Material In

But if you are never to scrape loose material over the surface, you are wondering how you are ever going to get that loose gravel packed back into the road. You must have a binder to make it stick, and should there be clay added to that loose material on the side you wouldn't have a mat thick enough to have much strength if it were scraped in. So the first operation should be to cut the road surface, preferably with a road grader, and obtain enough loose material to make a mat thick enough to allow the stones that protrude after last scraping to be rolled in by traffic. The wheels, when passing over the road, first touch the stones sticking up and force them down, and pack the fine material around them. For this reason do not scrape the road too long when there is the possibility of it drying out before all the surface is rolled. Excessive scraping tends to bring the coarse material to the top and then there will be more or less that will not get rolled in, because traffic is packing the binder down at the same time you are tearing more stone loose with the scraper. The entire mass must go down together to be successful. Immediately upon the drying out of the road, all loose stone should be scraped to the side and off the traveled track. *When the road is dry, scraping out should always be done with a light pressure on the blade* so as not to disturb the imbedded stone. When practicing this method, do not tackle more road than you can finish—if you are not sure you can finish two miles, take only one and finish it before leaving.

When scraping out, scrape lightly. You don't want any more loose gravel on the roadside than is necessary. The only reason for dry-weather scraping is to keep the loose material off the surface. The instruction above relative to scraping in when it is raining does not mean that clay must necessarily be added: but that, before you scrap in, scrape out, cutting hard at first. Cut the centerline to get binder to mix with the material you will later scrape in.

The Correct Road Shape

All roads must have a crown for the purpose of shedding water. This is the only need for a crown, so it shouldn't be greater than that need requires. An excessive crown causes a scuffing action of tires in a driver's efforts to keep his car on the road. Such a scuffing creates unnecessary wear by tugging at the road surface, tending to tear loose some of the compacted material. It is important, therefore, that we maintain the right crown. A crown ½ inch to the foot is about right for gravel roads. The crown will naturally vary with the width, and the correct crown can be determined by taking one-fourth the width of the road in inches. For instance if a road is 24 feet wide, it should have a crown of 6 inches. This will provide a rapid run off for the water and not contribute to unnecessary wear.

Although the total crown may be 6 inches for a 24 foot road the surface of the middle half is flatter, having only ¼ the total crown, or 1½ inches at the quarter line and the balance of 4½ inches from the quarter line to the shoulder edge.

The underbody truck scraper is the most economical method of floating a gravel or dirt road, but this method has its defects. The blade, not being rigid, tends to create waves by cutting where the surface is soft more than it does where it is hard. Subsequent scrapings exaggerate these waves and the road loses its original shape. For this reason, reshaping should occasionally be done with a grader. Traffic will tend to assist in rolling and compacting the road if given a chance. Scraping if not judiciously done will do more harm than good. More loose material is created by the scrapers than by traffic, and this is objectionable. Loose material has no value and should be avoided. Again let me say that when scraping does not make or leave a road better than it was before scraping, it is better not to scrape; the time and effort should be spent where it is needed and an improvement can be made.

Another feature in scraping that is objectionable is the high and low bumps created where a gravel road connects with a bridge or pavement. These high bumps are caused by the scraper dropping excess material as the blade is raised when the truck approaches the bridge or pavement and the low bumps by the blade carrying material away. To overcome this trouble, the scraper should occasionally cross over to the left hand side when raising and lowering the blade at the junction of the gravel with a bridge or pavement. This will eliminate the objectionable high and low bumps which so frequently exist at these points and will improve the smoothness of the road and its safety for the traveling public.

County highway truck with scraper underneath and a highway sander in the rear

Construction of a Model of a Purification Plant

By ROBERT S. MILLAR
Manager, St. Joseph, Mo., Water Co.

PROBABLY nothing attracts the attention of the general public more surely or holds it longer than an operating model of anything. Whether it is in a convention exhibit or in a store window, and whatever it is a model of, this seems to hold true. Therefore, when a waterworks department or company wishes to attract the attention of the public to itself or to explain how an existing or proposed water purification plant operates, the surest way to do both is to place a model in their office, preferably near the window where "the man in the street" can see it. The model may duplicate the plant in miniature, showing the buildings, pipes, valves, etc., or it may show the process without duplicating the appearance. It is seldom possible to do both in the same model. Nor, in the former case at least, is it possible to duplicate purification results accurately.

Many superintendents have adopted this plan; perhaps others would be glad to if they knew how to make a model. The following description tells how a model was made for the St. Joseph Water Co., St. Joseph, Mo., by Messrs. Pauli, Bumbacher and Smouse, chemist and engineers of the company.

The model follows very closely the major processes in the purification of the city's water, but no attempt is made to follow the proportions or appearance of the plant. There are four principal features—a sedimentation basin, coagulation basin, sand filter, and clear water basin. In addition there are the chemical feeders for alum, lime and chlorine—three bottles with 2-hole stoppers; a $\frac{1}{6}$ h.p. electric motor, a pump (taken from an old automobile); and necessary piping, valve, baffles, troughs, etc. The plant rests on a 52 x 22 in. table, the top of which is 27 in. above the floor. Under this stand two steel barrels, each 16 in. diameter by 18 in. high, one containing turbid river water (turbidity about 1000 ppm), the other clear water. The pump can draw water from either barrel, through a suction hose, and discharge into the settling tank, or into the grid system under the filter for washing same.

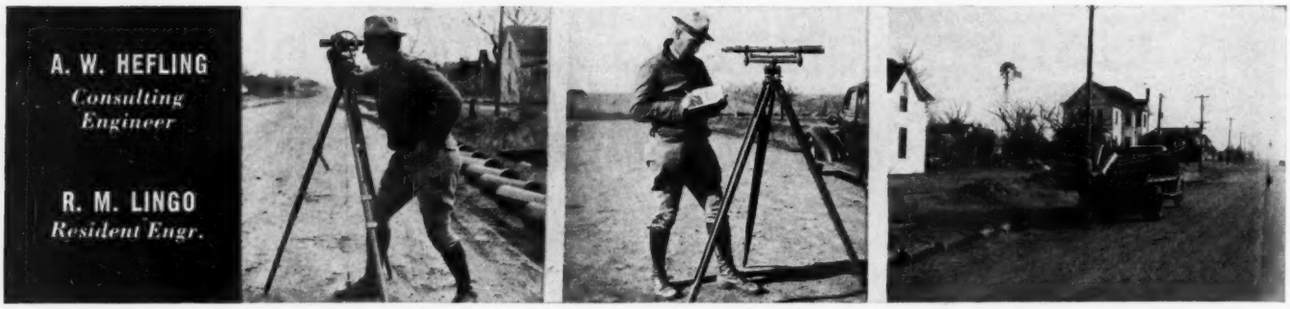
All pipe used in the model was $\frac{5}{8}$ in. tubing. The settling basin, coagulation basin and filter are made entirely of plate glass, except the bottom of the filter is metal, and are built as are aquariums. The frames which hold the glass are made of $\frac{3}{4}$ x $\frac{3}{4}$ in. angle iron riveted together at the corners and to four legs of aluminum castings which support the tank. The glass plates are fastened into the frame with aquarium cement, which is used also for sealing all joints. The settling and coagulating basins are each 14.5 x 20 in. and 12.5 in. high. The settling basin stands $9\frac{1}{2}$ in. above the top of the table and the motor and pump are set under it. The coagulating basin stands $6\frac{1}{2}$ in. above the table and the filter $5\frac{1}{2}$ in.

The first settling basin has a surface baffle 6 in. deep and extending the full 14.5 in. across the basin at a point 7 in. from the inlet. A copper trough is suspended from the angle irons about $2\frac{1}{2}$ in. from the outlet end of this basin, into which water flows from the surface,

Photograph of model of purification plant.

and from the trough, through a pipe, to a trough at the end of the coagulating basin; the pipe passing through a hole cut in the side of the settling tank and resting on the top frame of the coagulating basin. On a small platform constructed over the outlet of the former are two bottles containing solutions of alum and lime, which are siphoned out into the effluent, the amount being controlled by hose pinchers.

The second basin contains a slotted baffle made of metal, 5 in. from the inlet, which extends from the top to the bottom of the basin. The effluent from the second basin flows out over the top of two vertical risers, which are connected by two ells and a tee to a single vertical pipe which passes through the glass bottom, over to the filter, and up through its bottom, rising to a point about 1.5 in. above the level of the sand. There is 6 in. of sand on $2\frac{1}{2}$ in. of gravel. On the bottom of the filter is a grid consisting of a $\frac{5}{8}$ in. header and $\frac{1}{4}$ in. copper tubing laterals that contain 49 $\frac{1}{8}$ in. holes drilled in the bottom. From this grid the filtered effluent flows to a jar which serves as a clear water well, the overflow of which is piped to the clear water barrel under the table. Chlorine is applied to the clear water basin from a bottle in the same way as the alum and lime.



Hubs are put in line | Grade is established | Pipe is distributed along the line

Constructing Sewers for

By ROBERT MYRON LINGO
Resident Engineer for A. W. Hefling

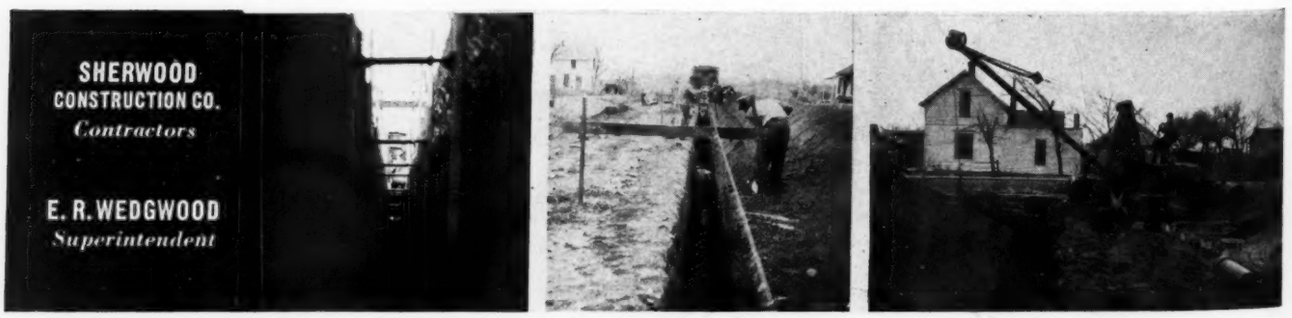
Excavating, laying and backfilling sewer at the rate of over 1,000 ft. a day as a PWA project, using ditching and backfilling machines and water tamping; including four tunnels under railroads and highways.

WHEN PWA funds were made available for municipal projects, the city of Wilson, with its 1,100 population, was the largest municipality in Kansas without a sanitary sewer system. To eliminate this undesired distinction, designing of a system was begun in the fall of 1937 and an application for funds to enable it to be built was allowed in 1938. Construction of the sewers began in September of that year and, except for cleaning up, was completed in 71 working days.

The town, surrounded by a farming community, with no industries or prospect of any, had apparently reached the peak of its growth, and the system was designed for a total population of 1,500. The ground was flat, and it was necessary to go 1½ miles to find a location for a disposal plant that could be reached by gravity, the point selected being 33 ft. below the highest point in the town. This necessitated a flat grade for the 8,303 ft. of 10″ outfall line, 0.20% being used as a minimum.

The system consisted of two mains and 43 laterals, all 8″ vitrified pipe, except 200 ft. of 8″ cast iron pipe was used for crossing under two railroads and two highways. All the sewers were located in either streets or alleys except about 1,000 ft., part of which crossed a plowed field and part was in tunnel under a building. A number of private cesspools and septic tanks had been built in the alleys, some of them in the path of the sewer, making a sweet mess when the sewer trench was dug through them. The total system contained 8,303 ft. of 10″ and 26,845 ft. of 8″ vitrified pipe and 200 ft. of 8″ c.i. pipe; laid in trenches down to 18 ft. depth (70% between 6 and 10 ft.); 82 manholes, 21 lampholes, 7 flush tanks and 440 wye connections.

The work was done under contract by Sherwood Construction Co. of Wichita, Kans., using ditching and backfilling machines made by W. G. Humphreys. The former, of the endless chain bucket type, cut so close to grade, that not more than half an inch had to be cut off by hand shovel. Working two 6-hr shifts a day, and jumping over gas and water services and mains, curbs and some storm sewers, 1,200 ft. was the best single day's run (digging, laying pipe and backfilling) and 7,105 was the best for seven consecutive days, digging a 9 ft. trench. The soil was slightly sandy, not hard, with no stones larger than 1 inch diameter, and there was no caving of trenches although the shoring was confined to 2 x 12's braced apart with jacks at 5 ft. intervals. Only two days were lost because of bad weather, and the rain then was most valuable for settling the trenches, 13,000 ft. of which had been completed but not settled. The specifications required settling with water, but the city water supply had failed and the contractor was up against it.



Sides of trench are shored | Pipe is laid to line and grade | Trench is backfilled

Water and gas lines are located

Trench is dug

Dirt piles out of the way

a Town of 1500

Before beginning construction, the engineer set grade stakes on a 6 ft. offset line, the pipe was strung along the street, and water and gas lines were uncovered or marked so the digging machine would not break them. Twice an unknown water line was cut and flooded the trench. Water services smaller than 1″ were cut when the machine reached them, and replaced when it had passed. Larger pipes were tunneled under. As the gas system had no valves, the trenching machine had to skip all the gas services, to be tunneled under. When an alley trench crossed a curb and gutter, the machine backed up to both sides and was able to dig under the curb, leaving very little hand digging to do.

All vitrified pipes were laid with cement and jute joints. When freezing of the joints was feared, laying was kept as close to the machine as possible—less than 30 ft. behind it—warm water was used in mixing the cement and freshly dug unfrozen earth was put onto the pipe before it had time to cool, never more than 30 min. later. At all times the excavated earth, which was finely broken up, was placed on the pipe very soon after it had been laid. Enough to fill up to mid-depth of the pipe was placed first and tamped well; then about 12″ more of earth was added and tamped. The rest of the backfilling was put in by machine, the fine earth running in almost like water. After the manholes had been built the trench was flushed with water, using approximately 5 gal. of water per cubic yard of earth, and allowed to settle for at least two days, when the top of the fill was almost level with the street.

At two places the railroad was tunneled under without interrupting traffic. Trench was dug by machine up to within 25 ft. of the tracks on both sides and the remaining 75 ft. tunneled by hand, from both sides at once. The grade here was some 10.5 ft. below the surface. Frames of 2″ x 6″ timbers 3 ft. square were made as tunnel lining. The tunnel heading was dug by hand 6″ ahead and a frame of timbers wedged into place, first the top and bottom ones being placed and the side ones then driven between them. After "holeing through," the pipe was placed at the time giving the longest interval between trains. The bottom and side frames were first removed, the top ones being held up by longitudinal pieces supported by jacks. The 8″ cast iron pipe was then set to line and grade and jointed. The entire crew was new at this work and sighting in for grade was slow. In one tunnel a level was used with a shim fastened at one end of such thickness as to give the exact grade when the bubble was centered. In the other tunnel the pipe was graded by backsighting on the pipe outside. When the pipe had been laid, the tunnel was filled with hand-tamped earth, beginning at the center, the frames and jacks being removed as the earth took their places. The time required for the entire 75 ft. crossing was 22 hours with 4 men.

Forty men was the largest number used at any one time. After the 71 working days taken in constructing this system, five men worked about three weeks cleaning up—replacing cuts in sidewalks and curbs, removing dirt from narrow alleys, replacing fences knocked over by the machines in narrow places, etc. Common labor received 40 cts an hour and $1 was the highest paid, to machine operators. The labor cost for the entire job was $7,850.

Water is used to settle backfill

Time allowed for settling

Road is regraded and smoothed

Cleaning Mains With Big Air Bubbles

By ROSCOE R. HOWARD
Superintendent of Municipal Utilities of Slater

THE water supply of most cities contains many elements besides hydrogen and oxygen, and that from the wells of Slater, Mo., is no exception. Many tons of iron, lime, etc., are removed each month by a purification plant which partially softens, filters and chlorinates the water.

The first two years it was necessary to pull pumps, dismantle and clean them every four to six months. Now we do that chore only once a year and the last time we found one pump practically clean and not so much deposit in the other as accumulated in four months of the first or second year. This iron and other material that is deposited in pumps and pipe leading from pumps to aerator, seems to differ somewhat from that removed from the water by aeration and the lime and alum treatment.

The pipe line through which the purified water is pumped 6½ miles up hill to Slater (a 12-inch class C cast-iron main) remains clean; but the inside of the pipe line from the wells to the waterworks plant became coated with a material about the consistency of fresh new plaster on a wall, but with an undulating surface which retards the flow of water more than a smooth surface would.

Three years ago, the capacity of the two miles of 8-inch pipe line from the wells to the waterworks became reduced to that of a 5-inch pipe, so that the pumps of both wells had to run 24 hours every day to supply enough water; the static head at the well pumps was 50 lbs. per inch, but when both pumps were running the pressure rose to 90 lbs. per inch, showing a friction head of 40 lbs. per inch. Each pump has a rated capacity of 275 GPM, but both working together furnished only about 260 GPM. On cutting out a 4 ft. section of pipe (to be replaced with Dresser couplings) so the gap could be used for cleaning the pipe, we found a coating about a half inch thick covering the entire inside of the pipe. We therefore decided to try a method similar to that used successfully by water main cleaning companies, which send a turbine scraper or "Go-devil" through the pipe propelled by the flow of water. However, we lacked enough confidence to make a self-propelled scraper in one unit and turn it loose in the long pipe line—we could not free our minds of the thought of the awful calamity of having it stalled and lost somewhere in the pipe and the city out of water. So we made two "Doodle bugs." One, a sort of mechanical muskrat designed to race through the pipe dragging a No. 15 iron telephone wire, we made by stringing a dozen halves of copper ball valve floats on a quarter-inch rod, spaced two inches apart by large corks strung on the rod between them. The pulling power of that string of light hemispheres was surprising.

The three-quarters of a mile of pipe nearest the wells ran straight and level under a concrete highway. Where it came from under the highway it crossed Shockley branch, and this was one of the places we removed a 4 ft. section of pipe. The first "Doodle bug" pulled the No. 14 wire from the wells to this point, and by means of this wire we pulled a ¼ in. seven-wire steel cable through. (Because of the length, it was as much strain as the little wire could stand, and it broke several times but always on the end we were pulling outside the pipe.) Then, with that cable we pulled through the other "Doodle bug." This we had made from a heavy hoop iron such as is used to hold automobiles in freight cars. It had 48 spring scrapers, so arranged that it cleaned the entire inner circumference of an 8-inch pipe in one operation. We started both pumps and dragged that "Go-devil" through, the water discharging into the branch. This water was dark brown and thick and tons and tons of foreign matter flowed down Shockley branch before the water ran clear, indicating that that section of pipe was clean.

We cleaned another section of approximately 1000 ft. in the same manner. The remaining mile had several bends and was up hill and down and we were almost afraid to try it. Anyway, the pressure at the pumps had been reduced from 90 lbs. to about 78 and the flow of water had satisfactorily increased, so we postponed the cleaning of the remaining mile of pipe line.

In about three years, however, the flow was again retarded and the pressure at the pumps increased to about 85 lbs.

To clean the pipe, we opened it a mile from the wells. We attached a gasoline-driven portable air-compressor to a tap near the farthest well and started it filling its receiver to about 100 lbs. pressure. Then, with the pumps going at both wells, we turned the compressed air into the main; then closed the quick-opening valve and let the air receiver fill up again, then again blew it into the main, and so on and so forth. As the receiver was only about 16 in. diameter by 40 in. long, these impulses or big bubbles ran about two per minute. We believe a larger receiver would do even more efficient work.

It required the attention of one man to watch the compressor and operate the valve. Another was stationed at the outlet to observe the effluent. For thirty minutes the water flowed clear and clean, then turned brown and thickened up. The water was agitated and somewhat noisy and there seemed to be a slight vibration in the pipe line. The water continued to flow turbid for about four hours, then began rapidly clearing up, so that at the end of six hours it was clear and clean. Two days later we cleaned the second mile in the same manner.

We have not yet tried it on city water mains but believe it will clean them very easily. We have some water mains forty years old that have not been cleaned since they were laid. We believe that, by proper manipulation of valves, the air can be introduced through a simple attachment made to fit a fire hydrant and that the sediment can be washed out from a 4″ or 6″ main through a hydrant several blocks away.

From our successful experiment we believe this method simply requires a rapid flow of water alternating with big bubbles of air—the bigger the better—the cleaning action being caused by the agitation by the swiftly moving wall of water that follows the big bubble of air.

Of course we do not believe it will remove hard scale from pipes, but we believe it is an easy way to rid pipes of the ordinary deposits and we are glad to give this idea to all pipe cleaning companies and water works men.

BASIC TABLE 1. FULL FLOWING PIPE. 2 FOOT DIAMETER, CIRCULAR.

"S"=.001. Assumed roughness coefficient, "n" is, for sand .025, and for pipe, .015.

1. Sand depth, proportional part of diameter	0.0	0.05	0.10	0.20	0.25
2. Sand arc, ft	0.0	0.906	1.291	1.850	2.094
3. Pipe arc (circumference less sand arc)	6.283	5.375	4.992	4.433	4.189
4. Sand chord (flat bottom) ft	0.0	0.877	1.204	1.597	1.732
5. Net "P" (pipe arc plus sand bottom) ft	6.283	6.252	6.196	6.039	5.921
6. Sand bottom, proportional part of net "P"	0.0	0.140	0.194	0.265	0.292
7. Pipe arc, proportional part of net "P"	1.0	0.860	0.806	0.735	0.708
8. Sand segment area, sq. ft	0.0	0.060	0.165	0.444	0.614
9. Net area "A" (circle less sand)	3.142	3.082	2.977	2.698	2.528
10. Net "r" line No. 9 divided by line No. 5	0.500	0.493	0.480	0.447	0.427
11. $\sqrt{\text{net "r"}}$	0.707	0.702	0.693	0.668	0.653
12. Composite "n" (.025 x line No. 6 plus .015 x line No. 7)	0.0150	0.0164	0.0169	0.0176	0.0179
13. Net "C" value for net "r" and "n"	84.	76.	74.	69.	67.
14. Net value, ($A \times C \times \sqrt{r}$)	186.7	164.4	152.6	124.3	110.6
15. Gross value (3.142 x 84 x .707)	186.7				
16. Ratio of flows, sandy to clear	1.0	0.88	0.82	0.66	0.59

Flow in Pipes Containing Bottom Deposits

By V. W. WILLITS
Consulting Engineer

THE experience which led to the preparation of this article occurred with a low-velocity, gravity flow conduit of 30 inch diameter, circular, on .001 slope, during inter-city litigation.

It was required to find the quantities flowing across two boundary lines, without the delay and expense of two weir installations. However, heavy river sand had intruded through a broken siphon, and spread along several miles of the conduit, to overlay the concrete invert up to ¼ of diameter like a flat bottom to a "basket-handle" cross-section. This sand moved slowly, changing depth daily at gaging points, but showing a definite surface. Attempts to drag out all the sand in a limited time had failed. Having determined the hydraulic slopes, "S", between pairs of standard manholes, by means of rod gagings of water depth in the manholes and their elevations and spacings, the corresponding discharges for a clean conduit were taken from well known hydraulic diagrams.

Obviously, net values for area (A), and wet perimeter (P), and a composite roughness factor (n), had to be found, to get values of "n" and "C" that applied to pipes partly filled with sand. The mean sand depth at each pair of manholes was used. The following method of obtaining such values seemed most rational, no published data being found.

The accompanying figure of a half-section of pipe explains the terms used in computing the following basic tables of the ratio of the discharge through a pipe containing a sand bed to that through one containing no deposit. This ratio is expressed by the formula:—

$$\frac{\text{Sandy (net flow)}}{\text{Clear (gross flow)}} = \frac{\text{Net area (A)} \times \text{Net "C"} \times \sqrt{\text{net "r"}} \times \sqrt{S}}{\text{Gross area} \times \text{Gross "C"} \times \sqrt{\text{gross "r"}} \times \sqrt{S}}$$

The $\sqrt{S}$ cancels out; "C," as given in the published tables, depends on "S" and "n."

Using the sand depth in proportional parts of the diameter, the arcs and chords for net "P," and segment areas for net "A," are taken from published hand-book tables of circular chords and areas.

For another diam., D, with "n" at .025 and .015, use Table I and multiply geometrical items by D/2, or D/2 squared, or $\sqrt{D/2}$, as the item may require; (lines No. 6 and 7 are unchanged). With other values of "n," change line No. 12 accordingly.

FOR LESS-THAN-FULL-FLOW, a separate table for each sand depth is necessary, all items in each table being derived from Table I, by using the proper proportionate part of diameter for the air space, and deducting the corresponding sand arc or sand area. Thus: For a sand depth of 0.25 of diameter and air space 0.20 of diameter, "n" and "g" as above. From table I, net "P" is line No. 5, column No. 5 less line No. 2, column No. 4; while net "A" is line No. 9, column No. 5 less line No. 8, column No. 4, and net "r" is net "A" divided by net "P" above.

Diagrams and tables are great time savers in calculating flow in sewers and other conduits. But such conduits may have sand or other deposits (if only temporarily) in the bottom. The tables then do not apply: but a diagram and tables given herewith permit calculating for any such case as readily as for a clean sewer.

TABLE II, LESS-THAN-FULL-FLOW, 2 FOOT DIAMETER

Sand depth 0.25 diameter, with "n" at .025 for sand and .015 for pipe and "S" at .001. (Refer to Table I.)

17. Flow depth, proportional part of diameter	¼	½	¾	9/10	Full
18. Two pipe arcs (line 3, col. 5 minus air arc)	0.000	1.047	2.095	2.898	4.189
19. Net "P" (line 18 plus line 4 col. 5)	1.732	2.780	3.827	4.630	5.921
20. Net "A" (line 9 col. 5 less air area)	0.000	0.957	1.914	2.363	2.528
21. Net "r" (line No. 20 divided by line No. 19)	0.000	0.344	0.500	0.510	0.427
22. Sand bottom, proportional part of net "P"	1.000	0.623	0.452	0.373	0.292
23. Two pipe arcs, proportional part of net "P"	0.000	0.375	0.547	0.626	0.707
24. Composite "n" (.025 line 22 plus .015 line 23)	0.0250	0.0213	0.0195	0.0187	0.0179
25. Net "C" for above "S," "r" and "n"	0.	50.	61.	65.	67.
26. Net value, A x C x Vr	0.000	28.1	82.5	109.7	110.6
27. Gross full pipe (3.142 x 84 x .707)	186.7	186.7	186.7	186.7	186.7
28. Ratio of flow quantities, .25 sand, part full to clear full	0.0	0.15	0.44	0.59	0.59

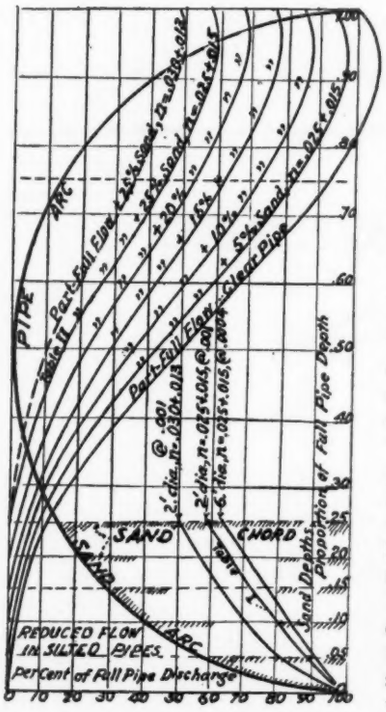


Diagram for calculating flow in pipes containing intruded sand

The graph herewith is for the probable limits within which sand or its equivalent could form such a false flow-line, and is precise enough for obtainable field data, so that interpolation will suffice. For example, the values in line 28 are found by following the first full curve at the left, noting the point where it crosses any "proportion of full pipe depth" line, and projecting this vertically to the horizontal axis. If the sand is only 10% of the depth of the pipe, use the fourth curve; if the sewer is filled with water to mid-depth, it carries 35% of the capacity of a full, clear pipe.

Repairing a Spillway With Gunite

During last fall and the spring of 1938, repairs were made to the spillway steps of Nepaug dam of the Hartford, Conn., water supply. A contract for the work was let for $15,977.50, this contract providing for resurfacing with gunite the concrete steps and crest sections of the spillway, from buttress to buttress, beginning 2.5 feet below the tread of the first (bottom) full step and continuing for the full height of the steps to the spillway crest, except for the tread on one step and the riser of another (which previously had been experimentally gunited), comprising in all an area of approximately 25,000 sq. ft. and an additional area of 5000 sq. ft. on the non-overflow portion of the dam and parapet walls.

Operations were carried on from the base of the dam, where the contractor's plant and equipment were set up. The procedure followed was briefly as follows: Loose and disintegrated surface concrete was first removed, which was then covered with 4″ by 4″ #6 steel wire mesh, securely fastened to the concrete by wiring to ¼″ expansion bolts set 24″ center to center. Gunite, consisting of one bag of cement and 3 cu. ft. of sand, after a thorough mixing in a dry state, was placed under pneumatic pressure with a cement gun.

An average force of 18 men (maximum 32) was employed by the contractor for the 77 days work was in progress. Shooting of gunite took place on 43 days, with an average use of 108 bags of cement a day and a maximum of 207.

Bibliography of Coagulation and Sedimentation

In our November issue we published a brief notice of a "Bibliography and Abstracts of the Chloramine Treatment of Water," published by the Works Progress Administration for New York City. Since then we have received another bibliography, on "Coagulation and Sedimentation in Water and Sewage Treatment." In this, the period from 800 B. C. to 1925 A. D. is covered just enough to "give a rough picture of the historical background"; that from 1925 to 1936 incl. is covered quite completely, and 23 items for 1937 are listed.

These 1076 items are indexed quite completely by subject, author, chronologically, and by the publications containing them. As a supplement, the book contains a German-English vocabulary of about 500 water and sewage treatment terms, which should be useful to those not familiar with the meanings of technical German words, many of which are not found in regular German dictionaries.

Like the chloramine bibliography, this one has been prepared under the direction of Lewis V. Carpenter, Director of Sanitary Engineering, New York University, with the Department of Sanitation of New York City as sponsor.

How to Carry Water Pipe

Experiments in carrying pipe, made by the Board of Water Commissioners under the supervision of D. J. Blackburn of Denver, Colorado, led, according to the National Safety Council, to this conclusion: Two men carrying two or three-inch pipe in 20 or 22 foot lengths should walk in step and hold the pipe on opposite shoulders. This causes better rhythm, less jouncing and less strain.

Seal-Coating Idaho Highways

Seal Coating Protects Investment in Oiled Highways, in the Same Way That Oiling Protects Investment in Surfaced Roads

By CLIFFORD HALLVIK and PHIL FORDYCE

IDAHO began the construction of oiled highways about 1928. Since that time approximately 2000 miles of the state system has been oiled. Developed in answer to a growing and insistent demand for hard surfaced roads, the state oiling program has proved to be a matter of economy in more ways than one. In addition to satisfying the need for dust-free, hard-surfaced roads, within narrow budget limitations, oiling of our highways has paid big dividends to the motoring public in the form of increased tire mileage, decreased wear and tear on motors and bodies, lower cost per mile of transportation, and safer travel.

In addition to these economies, recent investigations have further demonstrated the sound basis of our oiling program. It has been found that the increased speeds, heavier loads, and larger volumes of present day travel will wear away and throw off the highway approximately three fourths inch of surfacing per year. Stabilization of crushed rock or graveled surfaces by construction of oil mats largely prevents this yearly loss of surfacing. What began as an answer to a justified public demand for better roads proves to be, in the long run, an essential measure for protecting our investment in surfaced roads.

Seal coating bears substantially the same relation to oiled highways that oiled highways have to surfaced roads. It conserves our investment in surfacing and oiling and, at the same time, provides better, safer

The pictures below show the various steps in the process and the appearance of the completed work.

1. First step in the process is the application of heated asphalt to the roadway.

2 and 3. Close-up, showing the fan-like shape of the oil spray coming from the oil distributor. The sprays overlap so that the oil is applied evenly.

4. Half of the road is sealed at a time. Distributor is applying oil to the uncompleted section. The workman on the left is removing a strip of heavy paper used to prevent spraying of oil on the completed seal coat.

5. In the foreground oil and rock chips have been applied. On the right is the oil mat before treatment. On the left the road has been sprayed with road oil and is ready for spreading of rock chips.

6, 7, and 8. Three views showing the spreading of rock chips. This job requires skilled truck drivers. The trucks must travel in reverse in order to keep truck tires off the sticky asphalt. Also, trucks must travel at fairly high speeds to spread the cover coat material to the proper depth.

9. In the foreground is the black oil mat before seal coating, in sharp contrast is the light gray cover coat in the background.

10. Where possible, light colored rock or screened gravel is used for the cover coat. Here, the contrast between the black oil mat and the light colored rock chips shows how safety for night driving is achieved.

11. Recently completed seal coat job on the Yellowstone Trail near Kellogg.

12 and 13. Two sections of the Spirit Lake Highway which received seal coat treatment during the past summer.

14 and 15. Two pictures showing the texture of the completed seal coat. This surface tends to prevent skidding and eliminates the glare characteristic of many unsealed oil mats during rainy weather.

highways for the motorist. Even when constructed under ideal conditions, oil mats are slightly porous and tend to develop minute cracks during the curing period. These conditions, when not corrected, will permit water to enter the oil mat and become trapped beneath the surface. Freezing weather, plus this excessive moisture, results in frost boils, broken oil mats, inconvenience to the motorist, and expensive repairs during the summer months.

To prevent moisture from penetrating into the oil mat, and the ill effects that follow, the surface of the mat is sealed by the application of the proper grade and quantity of road oil. Suitable crushed rock, screened gravel or sand is then spread evenly over the oil application and rolled into the surface in order to make a close tight bond with the oil mat underneath. Use of rock chips or screened gravel will result in an improved road surface, which reduces the danger of skidding and diminishes the headlight glare common to many unsealed oil mats during rainy weather.

During 1938, some 21 miles on the Spirit Lake Highway, the Worley-State Line Highway, and the Yellowstone Trail Highway were seal coated as part of the construction program in District Five.—*Idaho Highways and Public Works.*

Catchbasin Connections to Deep Sewers

In order to limit the burden on the new Minneapolis-St. Paul sewage treatment plant it is necessary to remove from the existing combined sewers the storm-water from the streets and unpolluted water from air conditioning plants and other sources. To effect this in the downtown section of Minneapolis, with its deep basements and heavy traffic, the city has been constructing an extensive system of tunnels 90 ft. more or less below the surface in the soft St. Peter sandstone. This sandstone lies below about 30 ft. of limestone, which in turn is covered with 30 to 50 ft. of glacial drift. This sandstone is easily excavated and the city has already constructed many miles of sewer tunnels in it. In June, 1938, a shaft 10 ft. in diameter was sunk and sewer tunnels started from it in two directions, one toward the outlet and the other toward the retail and hotel district.

To bring to these tunnels the water from the catchbasins and other sources, drill holes are sunk vertically at street intersections to sumps and these connected to the tunnel with 4 x 5 ft. branch tunnels. At the top of each drill hole is built a basin 4 ft. diameter by 16 ft. deep. The drill holes are made 20″ diameter and lined with 14″ plain end "Mono-cast" centrifugal pipe, the space outside the pipe being filled with grout. The pipe stops about 7 ft. above the invert of the sewer and 4 ft. above the bottom of a 4 ft. diameter sump.

At the outlet of the sump into the tunnel is built a concrete dam 2 ft. high, to give a 2 ft. water cushion to receive the water dropping vertically 50 ft. or more; and the bottom of the sump is paved with 8″ of granite or vitrified blocks. The lower face of the dam is in the form of an ogee curve. A 4″ drain pipe through it serves to drain out the water cushion after the downflow ceases. A contract for drilling 36 of these holes and placing over 2,000 ft. of iron pipe therein was awarded to the Keyes Well Drilling Co. of St. Paul. Contracts for additional holes will probably be let later. The other work is being done by the employees of the Sewer Dept. under the direction of Frederick T. Paul, city engineer, and R. A. Huston, sewer engineer.

Cotton Fabric for Airport Runways

Cotton fabric has been used in surfacing highways in a number of states, but it is believed the use of it on two runways at Fort McClellan, near Anniston, Ala., is the first for this particular purpose.

The base for this surfacing is a red clay, gravel, sand and emulsified asphalt layer, 4 in. thick, which was constructed in 1-in. layers, rolled and sealed with asphalt. This was then covered uniformly with emulsified asphalt at the rate of 0.15 gal. per sq. yd., and before it had dried the cotton fabric was spread longitudinally in overlapping strips, and covered with emulsified asphalt at the rate of 0.10 gal. per sq. yd.; which in turn was covered with a mixture of aggregate (70% slag and 30% sand) and 29½ gal. of emulsified asphalt per ton, spread 1½ in. thick and thoroughly rolled with an 8-ton roller. As a seal coat, 0.15 gal. of emulsion was used, covered with sand at the rate of 5 lb. per sq. yd., broom-dragged until stickiness had disappeared, and rolled. Alternate sections were built in the same way but without the cotton, to test the value of the latter.

The cotton fabric is 80 inches wide, resembles loosely woven burlap, and cost approximately 17 cts. a yard. In building 3,400 ft. of 150-ft. runways there was used 288,000 gal. of emulsified asphalt, 2,500 tons of slag, 1,256 tons of sand and 20,000 lin. yd. of cotton fabric.

Springfield Saves by Reusing Pipe and Lead

In 1917, Springfield, Ill., constructed a 24-in cast iron main from a pumping station on Sangamon River to the waterworks plant. In 1936, a lake and a complete new station were constructed southeast of the city. By thus shifting the pumping load, the river main was no longer needed, but an additional line from the new station became necessary.

The old 24-in. line was found to be in such good condition, both as to pipe and jointing material that it was decided to reuse both. The lead was melted out and reused at an estimated saving of $1,850, while on the entire line of 15,536 ft. of 24-in. cast iron pipe, a saving of about $100,000 was accomplished by salvaging and relaying the old pipe line materials.

Building a Sand-Cement Road in Texas

In Kenedy County, Texas, the only locally available road material is sand, and the Texas Highway Department has built a section of highway, using cement to stabilize the sand, and uses this cement-sand mixture as a base for a bituminous-top highway.

A road-mix machine does the actual mixing. The surface is first shaped with a motor grader, then the cement is spread on the surface, ½ to ¾ inches deep. Following this, the mixer is passed over the road. This takes up the soil for any desired depth from 3 to 10 inches—normally 6 to 8 inches—mixes it with the cement, adds water, mixes, lays the mixture, smooths and tamps. This is followed by a tractor-drawn sheepsfoot roller, which completes the tamping; then by a pneumatic-tired roller; then by a motor grader which again shapes the surface to the desired cross-section. After curing, an asphaltic surface is added. J. W. Puckett is the division engineer in charge of the work; J. F. Snyder, ass't engineer, and George A. Houston resident engineer.

The Editor's Page

Better Highway Construction and Maintenance at Less Cost.

In the process of preparing a report on the mechanization of equipment for highway construction and maintenance, this writer was again deeply impressed by the recent developments in equipment that is available for this work. There are three important reasons for using good equipment: 1. It will do the work better, which means that the roads constructed by it will give better service and require less maintenance; 2. Greater rapidity of construction permits more needed highways to be built during a working season; 3. Construction costs less when efficient equipment is used.

Our magnificent transportation system would not be possible without modern tools. Roads built under the specifications and within the limits of tolerance of thirty years ago cannot carry modern traffic satisfactorily. There are some exceptions, of course, as brick pavements, but these do not apply to our low-cost high-speed surfaces which to-day are giving such magnificent service to the traveling public.

May we suggest to our readers that it would repay them and their communities if, during the next month or two, they snatch a few hours from their many duties and familiarize themselves with the newer developments in equipment for building and maintaining the roads for which they are responsible. We would like to hazard a guess that, assuming sound design, the general use of really efficient equipment would save over the next five years, at least 10% of the present bill for highway construction and maintenance, through economy in construction and reduction in maintenance due to better construction.

The Sanitation of Summer Resort Areas.

It is our practice each year at this time to publish an article calling attention to the need for sanitation in our summer resort areas. These are in no way meant as criticism of the various state health departments; rather the intention is to aid them in this difficult task by reiterating the need for a more critical attitude on the part of local officials toward this problem.

Admittedly there may be objections to spending money for a sewerage system and a sewage disposal plant that will be operated only two months in a year. But such objections are not sound—typhoid fever may be contracted by one meal eaten at an unsanitary resort. Summer resorts create a public health menace unless wastes are properly disposed of; and if they are on such a fragile financial basis that they cannot afford necessary health precautions, they are certainly no asset to a community.

Perhaps one of the best approaches to a solution would lie in a conference of the public health authorities of the various areas with the purpose of fixing and enforcing certain basic requirements. For instance, the New England and New York area could be treated as one unit, so that operators of resort camps and hotels refusing to meet the requirements of one state could not move to another state and retain their patronage. Fair and even treatment could be given to all.

Public health laws are far from perfect, and it may well be that the necessary authority for this action does not exist in all states; but the sooner steps are taken toward obtaining that authority, the sooner something will be accomplished.

Price Cutting in Public Works Field

If there is one field where quality should be the dominating factor in the purchase of equipment and materials, it should be among our cities, counties and states. No public corporation of this sort can afford to trifle with the quality of the materials that go into its streets, water supply systems or waste disposal facilities, or with the equipment that is used in constructing these. Both good materials and good equipment are necessary for good construction or uninterrupted and efficient operation. And surely, the best of materials is none too good for such jobs as purification of water, where a single slip may mean illness or death to the consumers.

Just because one material or one piece of equipment is lower in price than another is, of course, no indication that it is inferior. But when the price is lower than the price of known standard equipment or material, an investigation of the reasons why is certainly in order. Public monies should be wisely spent, with the determination that the public gets full value for their investment.

We have never agreed with the policies of the PWA and WPA that all awards should be made to the lowest bidder. As a result of this policy there is a lot of equipment in use to-day that cities, counties and states will pay through the nose for, because of excessive maintenance and upkeep, in the years to come.

PWA and the Water Works Industry

One of our waggish readers asks what the "pWa" has done in the water works field, and suggests that these be termed pWater Projects. According to information in this office, there had been, to the end of 1938, 2,421 waterworks systems approved for construction, the estimated cost on these being somewhat over three hundred million dollars.

There is no doubt that this construction has been a material benefit to the nation. It would be nice if it has also benefited the water works personnel that is responsible for operating these facilities. Tenure of office, opportunity for improving technical knowledge, and adequate compensation are three items that come readily to mind. Much yet remains to be done in all of these, we regret to say. Tenure of office is too often dependent on political favor. Perhaps more has been done in trying to get graduate engineers into operation than in providing opportunity for those already in the field; and in too many cases compensation is shamefully low in comparison to the responsibility.

Simple Dissolved Oxygen Sampling Device

BY LT. COL. FRANCIS E. DANIELS

Principal Chemist, Pennsylvania Department of Health

IN the absence of the more complicated devices for collecting samples of water, sewage or industrial wastes from tanks, ponds or streams, for dissolved oxygen tests, it is necessary to have a bottle fitted with two tubes, one to let the water in and one to let the air out in a way such that the air will not bubble through the incoming water. As the D. O. bottles have small necks, it is difficult to fit two glass tubes in a small rubber stopper and have the stopper still fit the bottle. So instead of the two tubes side by side, the writer has decided to put one tube inside the other for obvious reasons. This simple device, Fig. 1, can easily be made by any laboratory technician who has access to a blast lamp and some glass tubing.

A piece of tubing is selected of such a diameter as will fit the bottle when a short piece of rubber tubing is slipped over it in place of the rubber stopper. One end of this tube is heated and drawn down so that a short length of small rubber tubing may be attached to lengthen the column of air. A piece of smaller glass tubing is selected, closed at one end and a hole is blown in the side near the closed end. This blown hole is attached to the inside of the larger tube as shown, after which a hole through the outside tube is blown and fused down making a neat orifice leading directly into the inner tube, a procedure familiar to any laboratory technician. The smaller tube extends to the bottom of the bottle when the device is pushed into the neck and held tightly by means of the rubber band around the large tube. This large tube must not extend below the neck or else air will be trapped and the bottle will not fill.

When the bottle is plunged under water, the air escapes through the larger tube and the added length of rubber tubing, and water enters the smaller tube, quietly filling the bottle from the bottom.

The device may also be used in connection with other accessories such as pump, aspirator bulb, bottle, etc., for drawing more than one bottle volume in order to reduce sampling errors. But in most cases such refinements are not essential so that such a device as shown is all that need be desired.

A somewhat simpler device, Fig. 2, may also be constructed, especially if one has access to a turning lathe.

Take a solid rubber stopper about one quarter of an inch larger in diameter than the top of the D. O. bottle and cut in it a recess so that it will firmly fit over the top of the bottle like a cap. Then bore two holes close together near the center of the stopper and insert in them two tubes, one extending to the bottom of the bottle to admit water and one extending upward to discharge the air. On the latter tube, a length of rubber tubing may also be attached.

In this way the two tubes have room without distorting the shape of the stopper, and if thin metal tubes are used instead of glass, danger of breakage is eliminated. This could also be said of the device first described.

In the absence of a lathe, the recess may be cut with a large cork borer and a sharp knife.

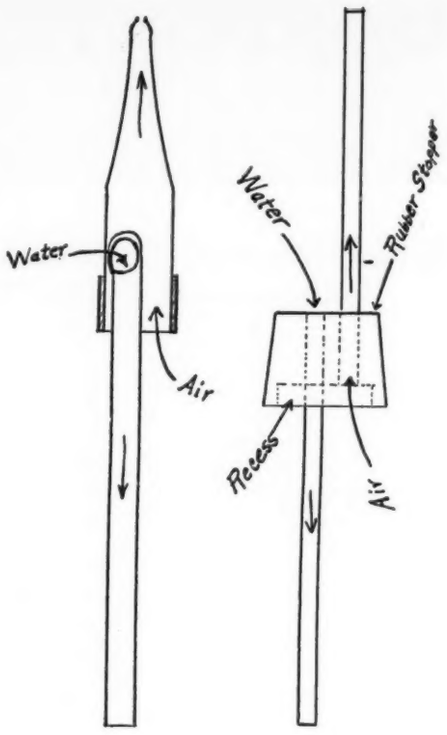


Fig. 1 (left)

Fig. 2 (right)

Equipment Used by a County Highway Department

Allen County, Kansas, has for four years been operating under the County Unit system, with 925 miles of road under its jurisdiction. (There are in addition 75 miles of State roads in the county.) At present the county is working on its secondary road system, surfacing them with crushed rock, using 600 cu. yd. per mile on a roadbed 24 ft. from shoulder to shoulder. Up to Dec. 20th, 1937, under W.P.A., the county had completed 106 miles of such new construction and resurfaced 60 miles, and continued similar work during 1938.

The drainage structures are made with walls of mortar masonry and roof slabs of reinforced concrete —a type utilizing relief labor to advantage. Sand is shipped in from Topeka, Wichita and Kansas City, but there is plenty of rock near the culvert sites to provide the coarse aggregate.

When starting in on the County Unit system it was necessary to obtain equipment for the work, and the county provided itself with 5 Diesel Caterpillar patrol graders, 4 large tractors and graders, two 100 cu. yd. rock crushing outfits, and one 200 cu. yd. outfit (capacity based on 8-hr. run). All three crushing outfits are double unit, a primary and a secondary crusher on each, so that all can be crushed to a 1-in. size, screened and filled into bins for loading. The bridge crews are provided with the necessary trucks, mixers and compressors.

The above information was furnished by A. W. Young, who is county engineer of Allen County.

Warfare Gases and Municipal Sewage and Water Plants

WARFARE gases as they may affect water and sewage treatment plants has become a live subject in England. The Air Raids Precautions of England has prepared and issued a memorandum for the protection of sewage works and sewage works employees, which has been pretty well discussed in some of the English technical journals. F. J. R. Batten in a paper before the North Eastern Branch of the Institute of Sewage Purification says: "This is a subject of the utmost importance and concerns not only sewage works managers, but also the health services. Fortunately, as yet, we have had no actual experience of the effects of the various poison gases at sewage works, but we think we can forecast with a certain degree of accuracy the dangers that are likely to arise should an attack be made on this country."

The gases that are considered include mustard and Lewisite, generally considered the most difficult gases to combat. Both of these are vesicants (that is, they attack the skin) and lung irritants, and Lewisite is also a systemic poison. The term "lung irritants" is not an entirely correct one, for the effects resulting from inhalation are far more deadly than they are irritating.

Therefore, it was recommended that protection be provided for operators, both from high explosive bombs and from gas from bombs. Protection was also recommended for equipment and machinery, so far as possible, by means of sand bags and other devices. Both mustard and Lewisite combine with and affect oils or greases, so that rubber hoods were advisable to protect pump bearings and other equipment that needed lubrication; these rubber hoods would also protect against sand or cement dust if a bomb should explode in the vicinity.

Most interesting was the discussion regarding the contamination of the sewage by mustard bombs, and the treatment necessary for safeguarding the operators at the plant from burns or gassing; and to protect the streams into which the effluent from the plant is discharged. An equalizing tank into which the flow might be turned to afford the greatest possible dilution was recommended; also, of course, chlorination to destroy the mustard. It was considered that there was some danger to workmen engaged in such work as pressing sludge, due to the mustard globules which might persist in the sludge for a long time.

It is the opinion of this writer, who has had some experience with mustard gas, that such danger would be very slight and that in plants of the types commonly used in America, at least, no danger would result to operators from operating plants treating sewage in which there were even fairly heavy concentrations of mustard. The danger that might occur from discharging the effluent resulting from treatment of a sewage containing mustard into a stream is more difficult to evaluate. A great deal depends upon the intensity of contamination, upon the type of sewage treatment, and upon the characteristics of the sewage. With reasonable precautions, a fair degree of treatment, and final chlorination of the effluent, there should be no danger. The chlorine dosage would have to be stepped up considerably.

Activated sludge plants and other types of treatment relying on bacterial action might have trouble, because mustard acts as a sterilizing agent, and even a small concentration would affect bacterial life and action. It is doubtful if sludge digestion tanks would be affected, because of the mass of organic matter in them.

What would happen to a water supply that might become contaminated with mustard or similar gases, and the methods available for protecting the water users against such contamination, is a real problem and one that should be given consideration. Open reservoirs might be subjected to attack by gas bombs as the surest way to depopulate or destroy an industrial area.

In view of the unreasoning fear that the general public has in regard to warfare gases, there is every reason to feel that very prompt and complete measures would have to be taken in case of contamination of the water. There seems no doubt but that a public which has been educated to regard with suspicion and even fear any slight taste or odor in the water (or even turbidity or color, in many cases) would be tremendously alarmed at tastes, odors or discoloration due to, or even appearing in waters subject to, gas contamination.

Treatment methods must therefore be of such a nature as not only to remove substances that might cause actual personal injury to persons using the water, no matter if this injury be slight or serious, but also to remove possible tastes and odors, and to maintain a high standard of appearance.

If this complete degree of treatment were not provided, it is likely that under the influence of fear, water would be used from many unauthorized sources. Not only would there be a demand for bottled water far in excess of any capacity to fill it, but springs, old or abandoned wells, and streams would undoubtedly be used for water supplies. It is not hard to visualize thousands of people going out into the country with all sorts of containers to get "safe" water—from creeks, wells, ponds and lakes. Newspaper clippings record this very happening when tastes occur in water supplies. And if any considerable portion of the population should leave the city, they would still be faced with a problem of safe water.

The widespread use of such unsafe sources of supply as those already listed would result in a great deal of colitis, dysentery, diarrhea and probably also typhoid. To prevent this, complete treatment of gas contaminated water is necessary, unless it should be possible to by-pass

A perfect target for an airplane bomb.

all affected areas and reservoirs—sometimes, but not often possible.

Tests to determine the presence of and measure warfare gases in water exist, but are not yet standardized and developed to a satisfactory point as regards their use by many water plant operators. The existing tests are quite complicated and lengthy and, in the case of some of the more recently developed gases, even uncertain. The exceedingly complicated structure of most of these warfare gases, and the rapid changes that they undergo in contact with water, make their measurement very difficult. Tests are now undergoing development, with the hope of making them suitable for general use in water plants by the average water plant operator if this should ever become necessary.

Treatment methods have been developed whereby all or practically all of the contamination resulting from the use of the more effective commonly used gases can be removed. The procedures involve, in general, only the employment of standard equipment that is normally available in treatment plants or can be procured quickly; and the methods involve only comparatively slight modifications from standard practices in water purification.

Sanitation Problems for Summer Camps and Hotels

WITHIN the next three months, summer camps and hotels will be preparing for the 1939 season. One of the most important things to be considered will be sanitation. Despite the earnest efforts of many State Boards of Health, this matter has been a shamefully neglected one. Too many owners and operators will not realize that their investment depends directly upon health conditions, and that a case or two of typhoid fever, or even of a less serious disease, will practically close a camp or hotel for the season.

This situation furnishes both a responsibility and an opportunity for the engineer. It is his responsibility to cooperate with local and state health officers and chambers of commerce in determining conditions that are a menace to health, and in insisting on their correction as a matter of safety for his community. He has an opportunity of doing the work that is needed to correct these hazardous conditions. He can plan, prepare the specifications and supervise the construction of facilities for safeguarding the water supply and for disposing properly of the sewage.

Camps and hotels, as a rule, open in late June. Construction should take no more than a month. In most cases, plans must be approved by the State Departments of Health. Therefore, an early beginning is necessary. The engineer should first obtain from his State Department of Health, if he has not already done so, copies of the rules and regulations governing camp and resort sanitation. He should also secure necessary data on equipment needed—water chlorination and treatment devices, and materials for disposal of sewage. With this available, preparation of the plans will generally require but a short time, since most of the jobs are small. If construction is begun in late May, completion is usually easily possible before the season opens. Most of the State Boards of Health will be found to be most cooperative in quickly approving properly prepared plans so that these projects can be completed before the opening of the summer season.

In addition to the work of providing a safe water supply and an adequate method of sewage disposal, swimming pools offer many problems in sanitation. Most states have adopted regulations covering the bathing load, necessary treatment of the water and other factors. The engineer should provide himself with the regulations from his state covering these and other factors that govern design.

Factors in Safeguarding the Water Supply

In the average camp or resort hotel, filtration of the water is not possible because of the cost involved, desirable though it may be. The primary step is chlorination because no other method of treatment available is so efficacious in making a water safe. The best insurance against a suit for damages from diseases that are carried by water is proof that a chlorinator was operating properly throughout the camp period.

Chlorinators are available in sizes and types to meet almost every condition of use. These can be operated with or without electric power; there are types that will function with or without water pressure; chlorinators can be installed in connection with pumping units, to start and stop with them, and to vary dosage in accordance with the rate of pumping; a very small amount of space is required for housing; operating conditions on summer installations are relatively easy, and heating and other provision for cold weather are not needed.

Tastes and odors can be controlled or eliminated. If tastes develop with chlorinations, an ammonia-chlorine unit will obviate these. If a taste has to be removed to make the water satisfactory, activated carbon filters will be found to be efficient and reliable. These are available in the form of pressure filters, so that they can be installed in a gravity line or in the discharge line from the pumps.

State Boards of Health will furnish more detailed design data, which are especially valuable because they are based on a knowledge of local conditions.

Disposal of Liquid Wastes

The sewage, wash water and liquid kitchen wastes form a problem in disposal that is probably second to no other. In general, for the smaller installations for camps and camp buildings and summer hotels, the small septic tank is the cheapest, and most fool-proof equipment that is available for primary treatment.

For computing capacity, follow the directions of your State Board of Health. The New York State Department of Health estimates that the average camp will

produce 25 gallons of sewage or other liquid waste per person per day. It is good practice to allow a little extra capacity. It is better yet to find how much water has been used, which can often be done by checking capacity of pumps and hours of pumping, or computing capacity of elevated tanks. For summer hotels, an allowance of 75 to 100 gallons per person is best, the allowance being governed by water pressure and records of water use.

When estimating needed capacity, peak loads should be considered. The average hotel has a much larger population over week-ends than at other times, and this is the load that should be considered. The same is generally true for camps.

It is often better not to concentrate the sewage into a single unit for treatment. Disposal of the effluent then becomes a major problem. If there are isolated cottages, a small tank and disposal area for each of these may cost less than a sewer system and a single large disposal unit. In some camps, for instance, one tank can be installed to handle the bath house waste; another the waste from the kitchen; a third that from the office or executive house, etc. These individual tanks should, of course, be ample in size for the task they have to do.

This advantageous procedure is possible only where the soil is sufficiently porous and open for underground disposal without danger of seepage toward or into water supplies. Under such conditions, a subsurface tile seepage field is usually the cheapest method of final disposal, and also the most troublefree. Resort areas are, as a rule, occupied only during the months of July and August, during which time soil conditions are usually at their best for this method of disposal. However, advantage should not be taken of these factors to skimp on either tank capacity or disposal field area.

Where soil conditions are such that subsurface disposal is not possible, other means must be considered. The small trickling filter has many disadvantages, but, in this situation, one major disadvantage. It requires a ripening period, during which the degree of treatment may be unsatisfactory. For this reason, some State Boards of Health are not willing to approve of this method of final treatment. The same applies to small contact beds. Sand filters have the advantage that there is a mechanical straining which effects considerable improvement, regardless of any biological action. If not covered, they are apt to cause nuisance, however, through the production of odor.

Septic tanks are the simplest and best means of primary disposal; and are much preferable to other types, as Imhoff tanks, for any job with a flow of less than about 20,000 gallons per day; even then they have no outstanding disadvantage. The metal tanks, made and sold commercially, have many advantages over built-in-place tanks. The metal tanks are well-designed, and give equal length of service. They are often cheaper. Moreover, they require less time and less supervision on the part of the engineer during installation. In the case of a concrete tank, continuous skilled supervision is needed throughout construction; with the metal tank an inspection before it is covered up will determine if it has been properly installed, and any changes that need to be made in setting, etc., are a matter of only a few minutes.

In caring for kitchen wastes, a grease trap should be installed between the kitchen and the septic tank. This may also be desirable with bath wastes. Wastes that do not contain sewage, while apt to be just as potent from the nuisance angle if not properly disposed of, do not present the same menace to health.

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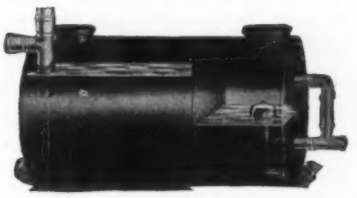

For parks, camp sites or other larger plumbing installations outside the sewer areas, specify the San-Equip Septic Tank with built-in siphon unit. Installation features which include improved intake design make this system more practical than higher-cost, individually-built tanks.

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How to Maintain Highways and Streets

Prepared by

W. A. Hardenbergh and Consulting Staff

This is the second of a series of articles covering maintenance of highways and streets. Tentative scheduling of the remaining articles is as follows: MARCH: Roadsides; structures; plant and equipment; handling and storing materials; earth and gravel maintenance. MAY: Maintenance of bituminous, brick, concrete and other surfaces. JULY: Soils in highway maintenance. AUGUST: Equipment and materials used in maintenance.

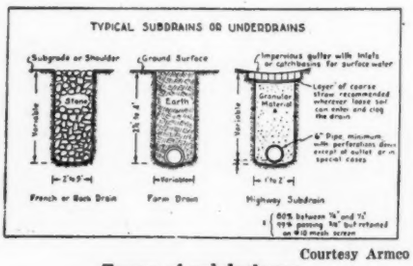
Maintenance of Paved or Lined Ditches. —When holes, depressions or buckling occur in lined ditches the necessary repairs should be made promptly as a heavy rain may greatly increase the extent of the damage. In stone or macadam gutters, holes should be thoroughly cleaned and stone and bituminous materials added. Where the section has become depressed, more of the material used in the original construction should be added to build up the line to the proper elevation. If the damage is due to underwash, this should be corrected. Concrete gutters that have settled, heaved or buckled should be removed and replaced at the correct elevation, the material under the replaced section being well compacted, and steps taken to prevent undermining or undercutting. If buckling is due to expansion, a section of expansion joint should be inserted.

The velocity in lined gutters is ordinarily quite high. This tends to washing or undercutting at the downstream end of the section. Therefore special attention should be given to providing an apron or outlet that will not be damaged by heavy flows. If a hole scours at the lower end, it should be filled up with large stones, and the whole may be grouted together.

Preventing Erosion with Ditch Checks. —Another method of preventing erosion in ditches on slopes that are steep enough to cause washing is to use ditch checks. This method takes advantage of the fact that the ability of the water to carry material in suspension varies as the square of the velocity of the water. In other words, water moving at 2 feet per second will carry four times as much suspended matter as that moving at 1 foot per second; and at 3 feet per second, it will carry 9 times as much material. These examples are not strictly true for all soils, as the carrying ability is really dependent upon the size of the particles present; and water moving at 3 feet per second can carry particles 9 times as large and heavy as those carried by water moving at 1 ft. per second.

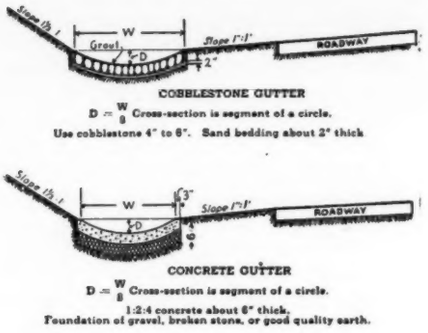
The prevention of erosion is obtained by building across the ditch a series of checks or weirs, which make the ditch, in times of usual flow, a series of quiet pools. The water passes over the checks as a series of small falls. In some soils, light and easily eroded, checks are desirable with a ditch grade of 1% or even less; 2% or 3% is usually the limit of grade possible without scouring.

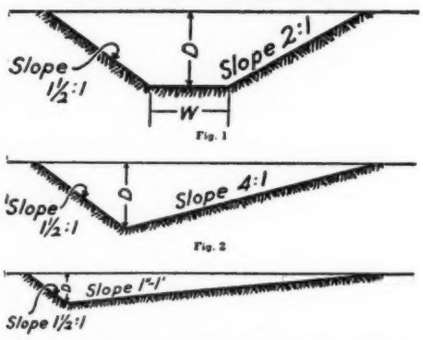
With checks, it is better to have a larger number of small falls of 9 to 12 inches than fewer and larger falls. Ditches are kept shallow and more nearly parallel the road surface with the small falls, and they are more easily maintained and mowed; also, if one check is washed out less damage results. The width of the weir or overflow section depends on the amount of water to be carried; it may be as much as 4 or 5 feet, but normally is less. The rule for placing checks is as follows: Allowing a 2% grade between checks, and a 2-ft. drop for the water, with a 4% road grade, the distance between checks, would be $100 \times 2 \div (4 - 2) = 100$ feet apart. With the same road grade, a 1 ft. fall and a 1% permissible grade for the ditch, the spacing would be $100 \times 1 \div (4 - 1) = 33$ feet. With grades over 5%, a paved gutter or enclosed conduit or pipe will usually be cheaper and more satisfactory due to the number of checks that must be installed. Checks may be made of corrugated metal, concrete, masonry, wood, logs, etc.


TYPICAL SUBDRAINS OR UNDERDRAINS
Subgrade or Shoulder
Ground Surface
Impervious gutter with inlets or catchbasins for surface water
Stone
Earth
Granular Material
Layer of coarse straw recommended wherever loose soil can enter and clog the drain
6" Pipe minimum with perforations down except at outlet or in special cases
French or Back Drain
Farm Drain
Highway Subdrain

Courtesy Armco

Types of subdrainage





These sections of ditches show common practice in construction. Three lower sections can be cut with a grader. (Courtesy Gohl)

Culverts

Culverts for carrying the water from one side of the road to the other are usually corrugated or cast iron pipe or concrete, various forms of the latter being used. Even on very small streams, a culvert diameter of at least 18 ins. should be used, as smaller openings may clog with debris. Culverts are ordinarily needed about every 500 feet on gradients of 3%, and every 300 feet on steeper grades, in addition to whatever culverts are needed for crossing streams.

The necessary opening of a culvert depends on the area drained, the rate of rainfall and the slope of the land; it is also affected by the kind of soil and its use, since a rocky area, for instance, will yield more runoff than a cultivated area. The culvert should not run full, or under a head except in extreme cases.

There are three general methods of determining the size of the culvert opening. (1) Inspection of the old culvert (to be replaced) or of culverts on the same stream above or below the site. (2) An empirical (or approximate) formula to determine the opening required. (3) Use of an exact formula to determine the amount of water reaching the culvert and then another formula to determine the size of the opening required.[1]

In using the first method, which may be supplemented by information from local inhabitants, an added allowance should be made if there is any question as to the capacity of the old culvert; and this allowance should be made large or small

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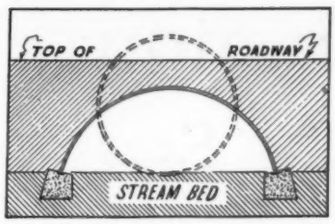
depending upon the damage that would result from an inadequate culvert.

The Talbot formula is most used for determining approximately what culvert area is required. This formula takes into account the area of the land draining to the culvert and its approximate slope. The formula is $A = CM^{\frac{3}{4}}$, where A is the waterway area required in square feet, M is the area drained, in acres and C is a coefficient that allows for the slope of the land.

The third method may employ the rational method of computing runoff, or one of the formulas generally used as substitute for the rational method, as the Burkli-Zeigler. This method is generally also followed in computing inlet and storm sewer sizes in cities. A detailed discussion of this appears in most standard textbooks on sewerage, and the application to storm sewer design was covered in an article in PUBLIC WORKS for June, 1934.

Culvert Location.—"The proper location of a culvert is important because it affects the adequacy of the opening, maintenance of the culvert, continuity of service and possible washout of the roadway."[1] Culvert location, in this connection, means its alinement and grade.

The first principle of culvert location is to make the alinement of the culvert coincide with that of the stream. The stream should have a direct entrance into the culvert, and also a direct exit. An abrupt change in direction of the flow at either end retards the flow of the water and



Half-round sections are used where headroom is limited

makes a larger culvert necessary. Where a stream flows at an angle to the road, it is better to use a culvert with the same angle across the road than to try to place the culvert straight across the road. A skew culvert or skew bridge is one placed at an angle to the centerline of the roadway.

Where it is necessary to change the direction of a stream, as is sometimes the case under very high fills, elbows with easy bends should be used. In such situations, consideration may be given to changing the channel of the stream; and in the case of a very crooked or irregular stream, this may be desirable. Such changes may not only improve the stream, but may so shorten the length of culvert required that the reduced culvert cost will more than pay for the channel changes.

The second principle of culvert location is to employ reasonable precautions to prevent the stream from changing its course near the ends of the culvert. If such change of its course occurs, entrance of the water into, or exit from, it may be affected to such an extent that water will be backed up and a washout occur. Riprap, sod or paving may be used to protect the banks from eroding and changing direction, and may also prevent deposits of material in the culvert.

The third principle of culvert location is to give the culvert the same general grade or slope that the stream it is to carry has in that immediate vicinity. There are some exceptions to this rule as when a broken grade line is used to prevent erosion at the outlet. In doing this, or in flattening the grade, it should be remembered that the silt-carrying ability of water varies as the square of its velocity, and a reduced velocity will cause sedimentation. Thus reducing the slope or grade of the culvert with the intention of reducing velocity may instead cause the culvert to fill up with sediment.

Placing a culvert on a steep slope so that it will carry more water, or so that a smaller culvert can be used for the same volume of water is likely to cause scouring and erosion at the lower end and to form bars of sediment beyond the outlet.

Other Factors in Location.—The most common mistake in installing culverts is to set them too low. In such a case, sedimentation may fill the culvert up to the natural grade line, reducing its effective area. Also, standing water will be retained in the culvert and will breed mosquitoes—not an important factor in some areas, but extremely important in others.

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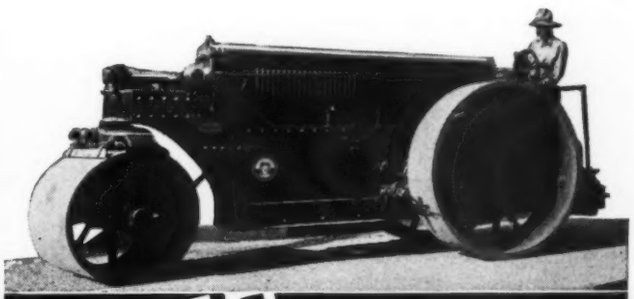

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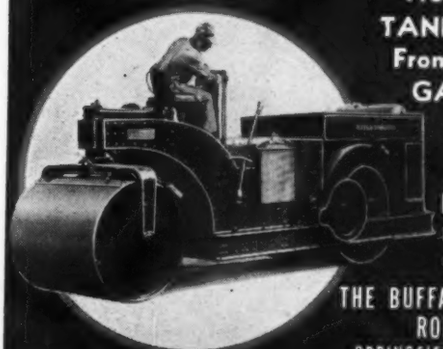

THE BUFFALO-SPRINGFIELD ROLLER CO.
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Where corrugated metal culverts are located at an angle to the road, a skew culvert, with the ends so cut as to be parallel to the centerline of the road can be used. These will be furnished by the manufacturers. Care must be taken in ordering these to insure having the correct skew angle or number. The angle should be measured clockwise from the centerline of the road.

Culverts carrying main road gutters across side roads and farm roads may be set back from the ditch line, and the main road ditch offset accordingly. The principal advantage is that a shorter culvert can be used while providing sufficient turning radius onto the main road.

Culvert Maintenance. — All culverts should be checked regularly to see that they are free from obstructions, that there is no deposit in them, that they are at the proper elevation and alinement, and that the pipe material is in satisfactory condition. Necessary cleaning and repairs should be made; inlet and outlet structures should be kept open and free from refuse and debris. This is especially important in the fall, in order that winter drainage will be properly taken care of.

When culverts have settled, heaved, become broken or are otherwise unserviceable, they should be repaired or replaced. If repairs can be made without disturbing the pavement surface, this is desirable, but tunneling is generally permissible only with the proper authorization. Men can work inside of larger culverts; repairs, as by threading new culverts through old and failing ones, are often possible.

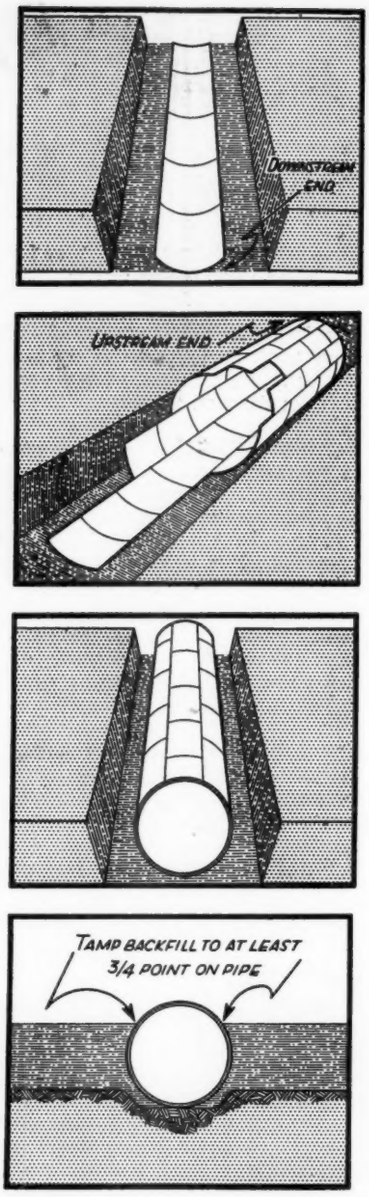
When a culvert needs repair or replacement, the reason for such need should be determined, if possible; also, notation should be made whether or not the existing culvert is of the proper size and type, if in the proper location, and at the proper angle with the highway; also whether filling up and replacement, or salvage is desirable. A factor in deciding on procedure may be future plans for the reconstruction of that section of the road.

In installing, a uniform and firm foundation is desirable; if the soil is very soft, it should be replaced with good material; the bottom of the trench should be shaped to fit the pipe; backfill should be selected material and carefully tamped in place. If local material is not suitable for backfill, proper material should be hauled in.

Particular attention should be given to inlets and outlets. If walls and aprons show evidence of undermining, stone, riprap or cutoff walls should be used to protect them. Cracked walls or aprons should be repaired, if possible; and as in every other problem in maintenance, an effort should be made to find the cause of trouble, as proper and lasting repairs cannot be made otherwise.

In the northern states, culverts may remain plugged with ice for some time after snow has melted from the road and the shoulders. Such culverts may be thawed with a steam jet or calcium chloride or salt.

Post markers are usually placed at the culvert, if the headwalls are within a certain distance of the traveled way, as mentioned under the section on Signs and Markers; also, in many states, post markers are placed at the outlet ends of culverts to locate these promptly even with a heavy snow fall. Most states place these markers on the right side of the channel, facing from the center of the road to the outlet of the culvert.



Erection procedure with multiplate culverts.

Thus it will be noted that culvert maintenance is simple, requiring primarily that the opening and the ends be kept free from obstructions or encumbrances, and that headwalls and outlets be maintained in good condition.

Bumps at Culverts and Bridges.—At culverts and small bridges, bumps or depressions frequently exist. These may be due to the natural settling of fills that were not properly compacted when the culvert or bridge was installed; or due to dragging loose material up to a bridge with a grader; or due to frost heaving.

When the defect is due to natural settling of fills, additional material can be placed and compacted on most types of roads. With concrete, the mud-jack may be used to bring the pavement slabs up to grade.

Heaping up of material on the right side of the road due to working with a grader, can be remedied by switching the grader over to the left side of the road on every other trip just as it approaches the bridge or culvert, so that alternate loads of road material carried by the blade, will be deposited in such a manner as not to cause a bump. Likewise, when starting on the other side, if there is a tendency for the grader to create a depression, a similar crossover can be made.

When the rise or bump is due to frost heave, drainage will not always correct the trouble because sometimes the culvert itself is raised by the action of the frost. Drains cannot be installed beneath the culvert. In such cases, it may be necessary to remove the unfavorable soil and replace it with granular material. Excavation may have to be made as much as 2 or 3 feet below the level of the culvert, depending on local conditions, and the granular fill should be tapered out along the road for some distance away from the culvert.

Jacking and Threading Culverts

Corrugated iron, cast iron and reinforced concrete pipe culverts can be jacked through a fill or under a road, thus eliminating trenching that would otherwise be necessary. Such pipe can also be threaded through failing masonry or wooden culverts. In jacking, the following procedure should be followed.[3]

Investigate carefully the material through which the pipe is to be jacked. Sounding with an earth auger is best. Follow the course planned for the pipe, and bore to an adequate depth. If rocks or large boulders are found, jacking may not be possible. Therefore this investigation is the first step.

It is most advantageous to jack from the downstream side. Even on a short culvert, 30-in. or 36-in. pipe is the smallest that it is practicable to use. On long runs, use larger pipe. In ordering pipe, tell the maker you intend to use it for jacking. Most of the manufacturers of corrugated pipe will furnish detailed directions and blueprints covering procedure.

The trench must be at the proper grade, and wide enough; there should be a cross-trench to permit riveting. A backstop is needed to take the thrust of the jack; guides and supports must be placed very carefully to insure proper alinement and grade. One 50- or 60-ton jack is normally enough, but it is well to provide an extra. If there is ground water, provide also a pump and a sump at the lower end of the excavation. A blower for forcing fresh air into the pipe for the workman in it is necessary in the smaller lines if over 30 or 40 feet long.

Shovel, hammer, pick and bar, all short-handled, are needed for working in the pipe. Dirt removed from the pipe end can be handled in small boxes pulled back and forth with a rope.

Once jacking has begun, it should never

cease, but should be carried on 24 hours a day. If operations cease for any considerable period of time, the pipe is very likely to "freeze" in position. Therefore provision for lighting and for extra shifts should be made. The average gang will consist of a foreman and five men. On small pipes, a rate of 1 foot per hour may be expected.

Subdrainage

Only in recent years has the importance of subdrainage as a factor in good roads been appreciated. When the subgrade or the soil under the road contains an excess of moisture, failure of the road surface is almost sure to occur. Such failures are evidenced by broken or heaved areas, which are not normally continuous, but occur only in spots or limited sections. It is these unsatisfactory sections that so often influence popular judgment to condemn a road as unsatisfactory, even though their area aggregates only a small percent of the total road area.

Subdrainage is really the control of surplus ground water by means of underground drains which intercept seepage or lower the ground water level. Contrary to general belief, subdrainage is neither mysterious nor difficult; nor is it costly. Judgment, observation, the use of a few simple tools, and the application of simple methods of control are all that are required.

The type of soils that are present are no doubt a factor in controlling subsurface water. A presentation of data on soils will

Armco Hel-Cor perforated pipe

appear in a later section of this text; but subdrainage can be accomplished without any special knowledge of soil conditions by following simple and fairly well standardized procedures.

Kinds of Subsurface Water.—The two kinds of subsurface water that affect highway structures are: 1. Capillary water; 2. Free water.

In extremely fine-grained soils, capillarity is more powerful than gravity, so that water will rise by capillarity in defiance of the laws of gravity. In soils that have coarser grains, the movement is more rapid, but the amount of rise is much less than in soils with finer grains. In a medium sand, water may rise by capillarity something like 18 inches above the water table; but in silt, which is a fine dirt (but coarser than clay) capillarity may cause the water to rise as much as 9 ft.; and in clay the rise will be still greater, but also slower. Thus it will be seen that even with a low water table, if the highway is underlaid with silt or clay, the water may rise by capillarity high enough to cause damage to the pavement or surface.

Free water, on the other hand, is under the influence of gravity and percolates through the soil, generally in a downward direction and roughly parallel to the ground surface. The porosity of the soil has an important effect on the rate of flow. It is well known that water will flow through sand, which has large grains and open texture, more rapidly than it will flow through silt, which has small grains.

Thus the capillary water, being affected only a very little, if at all, by gravity, is not generally drainable. To prevent it from reaching the subgrade and damaging the road, subdrains must be installed which will limit the height to which it will rise; or a porous layer of soil must be so placed as to intercept its rise, and this porous layer must then be drained. Free water, which is largely drainable, is the familiar "water table" which flows under the surface of the ground generally parallel to the ground surface. A drain can be placed to intercept this water and carry it to an outlet.

Procedure in Designing Sub-Drainage.—Before the drainage system is planned

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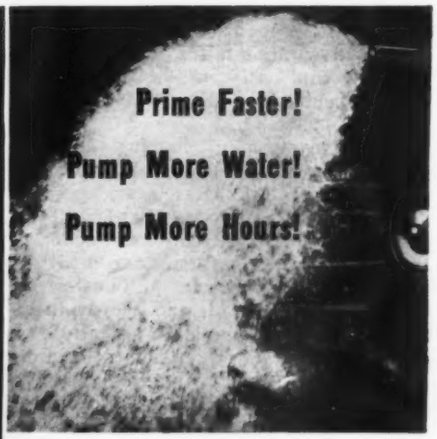

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a careful inspection should be made of the area. Generally, there has been too much guessing at underground conditions. The maintenance man faced with finding and curing the cause of a broken area of road surface, should look over this area carefully during the wet season or as soon after as is possible. Otherwise, the ground will dry out and it may be difficult to determine all sources of trouble.

Free ground water often can be seen flowing from the face of cuts in the shape of seepage and small springs. Free water can also be detected in the soil by making borings with the soil auger. Capillary moisture may make the earth in the upper layers appear very wet, but when the auger reaches the free water zone, water can be seen on the soil sample and water generally shows in the auger hole. Rock may cause complications, the more so that free water may follow the upper surface of the rock to a point of possible discharge.

Investigations should be made to a depth of 2 to 6 feet below the road surface. The depth of the drain will be determined largely by the type of soil. The free water must be removed to such a level that capillary water will not rise to the under surface of the pavement. If the layer of water bearing soil is not too deep—often this is comparatively shallow and underlaid with an impervious area—the subdrain should be placed at the bottom so as to shut off all flow of water under the highway. If the seepage zone carrying free water is deep, and a drain cannot be established at its bottom so as to shut off completely the flow under the road, the soil between it and the subbase should be examined to determine if it is of such character that capillary water will rise to the subbase. Usually it will not be, because if it is open enough to permit free water to flow through it, its ability to raise water by capillarity will be limited, and drains about 6 feet deep will ordinarily be sufficient.

Thus the steps in planning for subdrainage involve an examination of the soil so as to determine at what depth the seepage zone is located, to what height the free water rises, the type of soil underlying the highway, the best location for an underdrain that will cut off the flow of water under the road, and the depth at which it must be placed in order to (a) lower the free water sufficiently to eliminate trouble from this cause, and (b) lower the free water so that capillary water will not rise to within danger distance of the subbase. It should be remembered that the only source of capillary water is the free water; and if the free water is drained off there will be no source from which capillary water may rise to cause damage.

In the old kerosene lamp, a wick brought up the kerosene from the reservoir in the base by capillary action to a point where it could be burned. Certain soils act as a wick. When the kerosene reservoir is empty, the wick does not function. If the reservoir of free water in the soil is drained out, water cannot rise by capillarity.

Thus it will be seen that control of capillary water is normally accomplished by controlling free water. In a certain few soils, which have unusual ability to raise water by capillarity as much as 10 to 20 feet, this method will not apply; but such conditions are rare. When encountered they will be a special problem, handled generally by means of layers of porous soils.

Two Phases of the Problem.—There are two phases of this problem of removing free water. One occurs in normally hilly areas, where the ground water is always in movement downward to a stream or low area, incidentally passing under the road in its course. The other phase occurs in normally level areas where the ground water is high, as in swamps or wet sections. In such cases there is no movement of the water through the soil, or only a very slight movement, except for rise and fall during wet and dry seasons.

In the first phase, the interception of the seepage zone with a subdrain, and the discharge of the water to an outlet constitutes the solution to the problem. In the second phase, the complication is that while subdrains may be installed so as to lower the ground water level, if a free discharge is available, there is often no point where drains as deep as this can be discharged without pumping or the construction of excessively long and deep lines.

Kinds of Seepage.—The two common types of seepage whereby free water enters under the highway to cause damage are (a) sidehill seepage, which occurs in sidehill areas, due to the downhill movement of the free water in a zone roughly parallel to the ground surface; and (b) longitudinal seepage, where water enters under the road, normally at or near the high point of a cut, and flows under the road to emerge further down the grade. Usually this point of emergence or break up is at and below where the seepage zone reaches the surface of the road.

Kinds of Subdrains.—Among the types of drains ordinarily used for removing subsurface water are (a) the farm-type subdrain, which consists merely of a pipe in the bottom of the trench, with backfill of the excavated material; (b) the combination surface and subdrain, which is a trench with a pipe in the bottom, backfilled with porous material, as gravel or broken stone; (c) the intercepting drain designed and used primarily for highway subdrainage, which consists of a trench, with a pipe in the bottom, backfilled with porous material, but with the top sealed to prevent surface water from entering. These three types of drains are shown on page 24.

The purpose of the farm drain is to lower the water level in the ground but not to remove it entirely, since plant roots need water. Therefore, the level is maintained so that capillary water reaches the root zone. Moreover, rapid removal is not necessary, and a backfill of fairly impervious material is therefore permissible.

The combination surface and subsurface drain is used to a considerable extent for airport drainage. The open top permits the collection of surface water during rainy periods. A variation of this drain omits the pipe. This is the so-called French drain. Experience has shown that pipe is desirable for better drainage and much longer useful life without repair or replacement.

The third type of drain is intended to be most effective for one particular important job — that of intercepting the passage of water under the road where it may act as a reservoir for capillary water, and may also, of itself, cause damage. Surface water is ordinarily taken care of by other structures, therefore the sealed top is desirable to prevent clogging by the washing in of fine material. A fairly fine pervious or porous backfill, as shown, is advisable. In soft soils, this may be placed under the pipe also, to give it a better support, but not for the purpose of placing a subdrain beneath it.

For subdrainage work of the type being discussed, only the third type of drain will be considered here. The porous backfill, as recommended by Cotton, consists of material mainly between ½-inch and 10-mesh. The depth of the drain must be such as to reach into or through the seepage zone. The top may be sealed with asphalt or tar, with cement grout, or even with clay.

There are many types of piping used for drains, including ordinary drain tile, a special porous concrete pipe, and perforated metal and clay pipe. With drain tile, joints should be open; generally they are wound with burlap or roofing paper. It is desirable that such pipe, which are usually in short lengths, be laid on a 2 x 4 timber to insure the maintenance of grade. The same applies to the porous concrete pipe, which is usually also in short lengths.

The perforated pipe — metal is most generally used—ordinarily has perforations extending over only one-third to one-half the circumference. In most cases these perforations should be placed down, as this prevents clogging due to entrance of silt or small particles from above. There are some cases, as where the water may be lost into an open soil, where the perforations should be placed up. Perforated pipe should be used only in those sections where seepage water is to be eliminated; at other points, and especially at the outlets, a tight pipe should be used. A cap should be placed at the upper ("dead") end of the line, and the outlet should be screened to prevent the entrance of animals. Care should be taken that the outlet is free, and that silt or snow will not stop it up.

Installation details are recommended by Armco[1], who have made an intensive study of the problem of subdrainage, as follows, in summary: Pipe diameter should not normally be less than 6 inches, but a pipe larger than 8 ins. is rarely needed purely for subdrainage except for

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The next installment, which will appear in the March issue, will discuss roadsides; structures, including bridges; plant and equipment; handling and storing materials; and earth and gravel maintenance.

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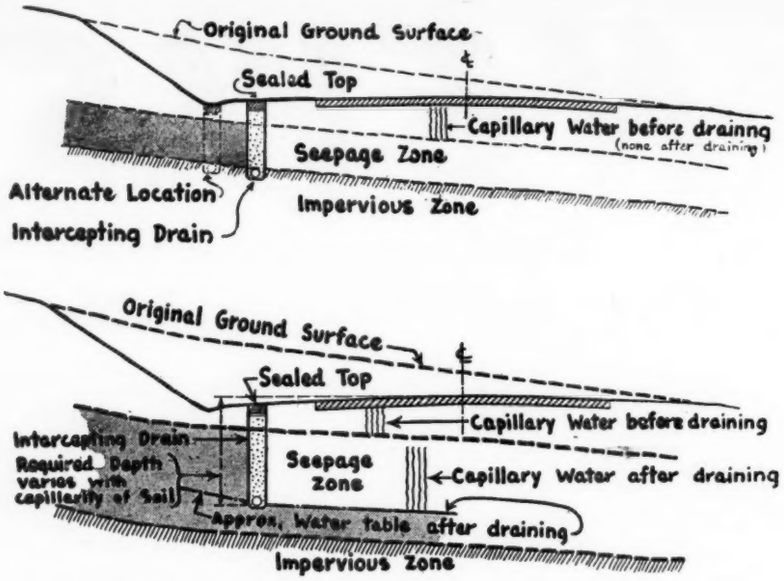


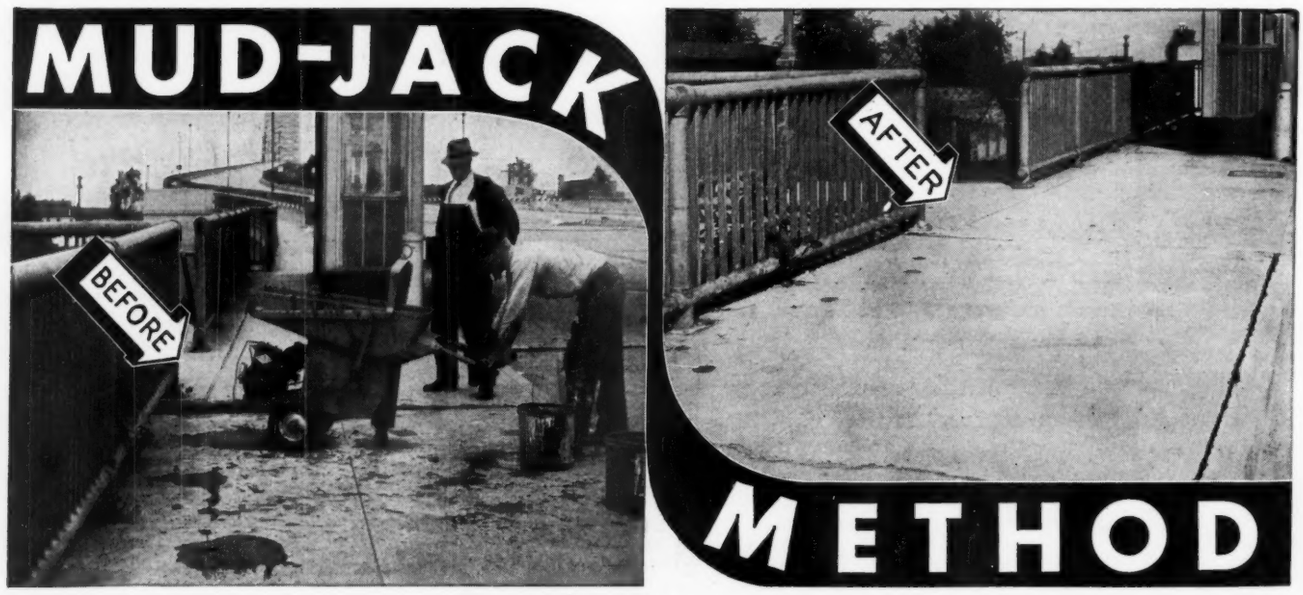
Treatment of shallow seepage zone above and of deep seepage zone below.

unusually long lines. Where surface water is to be handled also, very much larger sizes will be required. The slope of the 6- or 8-inch pipe should be at least 6 inches in 100 feet. The outlet should be high enough to provide a free flow at all times. The upper end may be plugged, but is sometimes turned up to provide ventilation. Connections between sections of the pipe should be firm and true so that a good and even grade is maintained. The trench width should normally be wide enough for men to work in the trench—12 inches on shallow trenches and 18 inches or even more on the deeper trenches. On longer lines, unless the grade is considerable, a transit or level should be used to give grades, so that there will be no flat or reverse slopes. The lower part of the backfill, which may be gravel or other satisfactory porous material, should be placed with care so as not to injure the pipe or destroy the grade.

Where possible, the pipe should be placed slightly below the bottom of the stratum of soil that carries the seepage water, but not into the lower impervious strata, for the reason that this may be thin, and if broken through may tap an additional seepage zone that may then have to be taken care of.

Treatment of Sidehill Seepage.—There are two general cases in sidehill seepage, which may be classed arbitrarily as shallow and deep seepage zones. In the case of a shallow seepage zone, shown herewith, the top of the seepage zone is 2 to 4 feet below the road surface, and the bottom is from 6 inches (which is unusually shallow) to 3 feet deeper, but the total depth is not more than 7 feet. In this situation, the agent that destroys the road is the capillary water which rises from this seepage zone to cause frost heaves or an unstable subgrade. The solution is shown in the illustration. An intercepting drain is placed on the upper side of the road so as to shut off completely the stream of underground water and prevent it from passing under the road.

In the second case, shown herewith, the seepage zone is so much thicker or deeper that it is impracticable to carry the intercepting trench down to the bottom and thus cut off all of the water passing under the roadway. From an examination of the soil under the road, a



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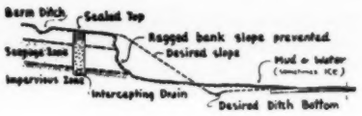
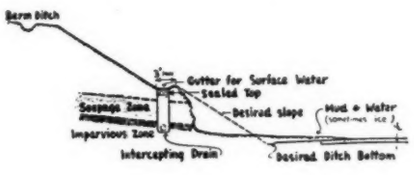


CASE I - LOW BANKS

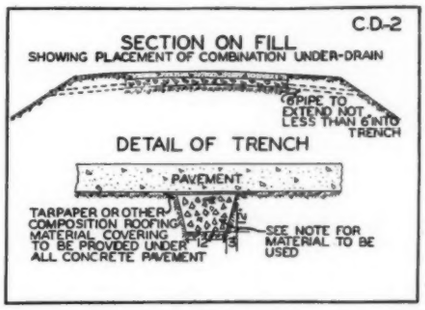


CASE II
HIGH BANK WITH SEEPAGE IN LOWER PORTION

conclusion is reached as to the probable height that capillary water will rise. If the soil is sufficiently open and porous to permit the passage of water through it, as indicated by the presence of a seepage zone, it is unlikely, it has been found by experience, that capillary water will rise more than 6 feet. Therefore, an intercepting drain 6 or 7 feet deep will so lower the free water in the soil that capillary water will not be a problem.

Treating Longitudinal Seepage.—Seepage water from hillsides may pass under a road at a considerable depth, as where a road is in cut. The construction of the road may change the course of this ground water so that it is easier for it to follow the course of the road and emerge near where the road passes from cut to fill, than it is to follow its previous course. This is called longitudinal seepage. The cause is the same as for sidehill seepage, that is, a seepage zone brings free water under the road.

This condition can be cured by an intercepting ditch. The details of construction are shown in the cut herewith.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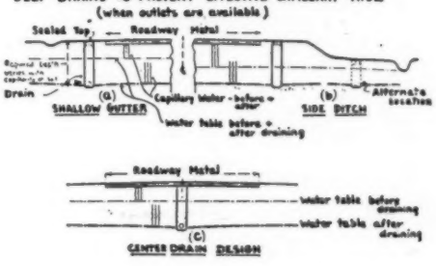
Treating Longitudinal Seepage

Other Conditions Needing Subdrainage.—Slides on the fill side of a road and also slips or slides of the faces of cuts are caused generally by this same condition of seepage. If seepage water flows along the top of a sloping impervious layer of ground, the weight of the soil above, aided by the lubricating action of the wet soil, causes slides. The remedy, therefore, is the interception and removal of the seepage water, so that the fill will be stable.

In the case of a fill on a sidehill, an intercepting drain must be sunk to the impervious stratum, cutting off the flow of seepage water. The methods of construction and use are just the same as for intercepting seepage under the road; in fact, the two conditions are the same, except that in drainage to prevent fill slides, the seepage zone may be so deep that capillary water will not rise high enough to injure the road. Therefore, trenches for preventing fill slides will normally be deeper.

In the case of a slip on the side of a cut, the same procedure is applied. If the slope of the water bearing stratum is steep, it may be possible to construct an intercepting trench and drain beyond the brow of the cut, and drain off the seepage water. Normally this will not be possible. If not, a surface ditch should be placed at the top to prevent surface water from running over the face of the cut, and an

LEVEL WATER TABLE CONDITION
DEEP DRAINS TO PREVENT EFFECTIVE CAPILLARY RISE
(when outlets are available)



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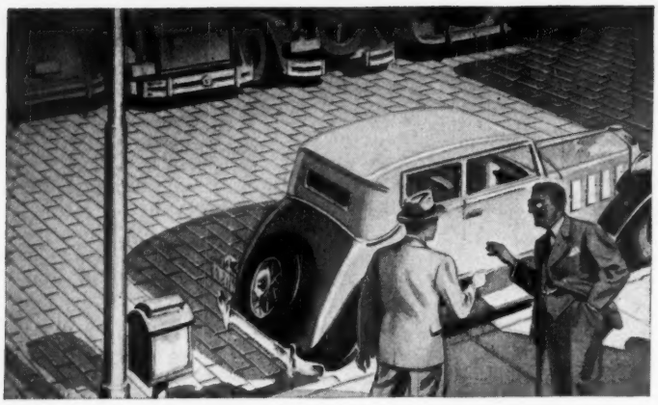

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intercepting drain constructed back from the point of emergence of the seepage water. Page 31 shows one method of handling this problem. Others may be devised, based on the general procedure already outlined, to meet special situations.

Subdrainage in Level Areas With High Ground Water

In level areas where the ground water is high, as in swampy or poorly drained sections, proper drainage is effected only by the prevention of the rise of capillary water. The height to which capillary water will rise depends entirely upon the type of soil. Therefore, the first step in planning for subdrainage, in areas of this type is to sample and examine the soil to determine its character and its capillary qualities. Data on soils and their characteristics will be presented in the section on soils.

The procedure for subdrainage in these areas, assuming that the soil is of such character that drainage will probably be effective, is: (a) By examination of the soil, the required depth of the subdrains is determined; (b) Surveys and measurements are made to determine where the water collected by the drains can be discharged, and the elevation of the outlet.

The elevation of the possible outlet and the length of the line will determine how deep the drains can be placed.

Location of Drains; Construction.—A single drain may be constructed under the center of the road, and at the required or possible depth; or one drain may be placed under each shoulder. Both of these are shown on page 31. Drains under the shoulder are generally preferable to the single center drain, for two reasons: (1) The water is intercepted before it gets under the pavement or roadway; and (2) the drains are more accessible.

The method of construction is the same as for drains for intercepting sidehill seepage, already described.

If the character of the soil indicates that deep drainage is necessary because of high probable capillary rise, but the topography is such that no outlet is available at an elevation sufficient to permit placing the drains at the required depth, another method must be adopted. Two are then available. Either the grade of the road must be raised, using porous materials, as gravel or sand; or a portion of the base must be removed and replaced with such porous materials.

Underdrains are then constructed to prevent the accumulation of free water in this porous base or layer. Transverse seepage trenches may be desirable to assist in the prompt removal of the water that collects in the porous layer. Thus, while water may rise into the porous layer, at times of high water table, it will be removed by the drains; and capillary water brought to the top of the impervious layer will also be prevented from accumulating under the roadway by the drains.

Bibliography References

These refer to publications mentioned in both the January installment and the present one.

1. Handbook of Culvert and Drainage Practice. Armco Culvert Mfrs. Assn., Middletown, O.
2. American Association of State Highway Officials, Washington, D. C.
3. Special Publication. Toncan Culvert Mfrs. Assn., Cleveland, O.
4. Field and Office Manual, Ohio Department of Highways, Columbus, O.
5. Nebraska, Department of Roads and Irrigation, Lincoln, Nebr., has a very complete classification.

The first installment of this article appeared in the January issue. The next installment will be published in March. Suggestions for improvement are invited. Readers are requested to send us copies of printed or mimeographed instructions for maintenance that they have prepared. See page 24 for scheduling of future articles.

The Waterworks Digest

Abstracts of the main features of all important articles dealing with waterworks and water purification that appeared in the previous month's periodicals.

Main Cleaning in New Rochelle, N. Y.

Since 1928 New Rochelle has cleaned 21 miles of 4″ to 24″ mains, about 8% of the total mileage. For 4″ and badly tuberculated 6″ and 8″ the machine is dragged through, for the others it is "shot" through with the water pressure. A 24″ main had its coefficient raised from 62 to 116, but in two years it had dropped to 75, most of it the first year. An 8″ main was raised from 36 to 108, dropping to 69 in two years. To remedy trouble with "red water," soda ash has been used to raise the pH from 6.8 to about 8.0. In the spring of 1936 the use of hydrated lime continuously was begun to prevent tuberculation, keeping the pH at about 8.6. It takes about three days to bring the pH to this point in some of the outlying parts of the distribution system. However, discs cut from the pipe in tapping show no evidence of lime deposit, and a slight formation of tubercles.[A22]

Standpipe Blown Over

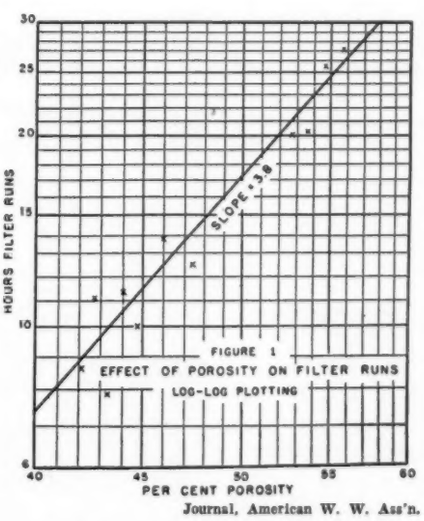
A standpipe in Norfolk, Va., 25 ft. diameter and 100 ft. high was blown over, while empty for painting, by wind of approximately 68 miles per hour. It was anchored by 10 bolts on a 28 ft. circle, each attached to the tank by 3 x 3 x ⅜ inch angles. The bolts did not part, but the bottom legs of the horizontal angles remained on them while the upstanding legs of these angles tore loose and went with the tank. There was no stiffening ring around the top of the tank, and this was forced in by the wind, which undoubtedly increased the wind pressure and this probably caused the collapse.[A23]

Emergency Repair Truck

Minneapolis, Minn., has recently built a repair truck provided with a work bench 12 ft. long equipped with drill press, vice, electric grinder and small lathe; beneath it a map compartment and drawers for files, scrapers, hammers, sand paper and small tools; a blower for ventilating manholes, etc.; fire extinguisher; socket wrenches, pails, etc. A 3,000 watt A.C. power plant; welding torch, large wrenches, pipe tongs, taps and dies. Rubber boots and rain coats; first aid kit; saws and hatchets. A 2½ inch gasoline centrifugal pump. Bins for bolts and nuts, large thawing blow torch, gasoline and kerosene cans and lanterns. A suction hose compartment 12 ft. long. Bars, shovels and picks, shaft pullers, electric drill, portable grinder and gear pullers, truck jacks, chains, tire tools, acetylene and oxygen tanks. A spot light, with weather-proof cords. Danger signals, wedges and blocking. A rear hangover is used as a field bench, with swivel vises and electric grinder. The roof has a long glass panel for lighting the interior. A motor-driven gate-operating device provided with a slip clutch.[A24]

Selection of Filter Materials

Previous literature indicates that (1) filtration takes place within as well as at the top of a filter. (2) Filter runs vary as the 2.15 power of the effective size. (3) The Baylis method of effective size determination gives excellent correlation of filter runs with filter material size. (4) Filter runs vary with the reciprocal of the 1.5 power rate of filtration, and (5) with the cube of the filter material porosity. (6) Runs on anthracite coal filters are longer than on sand, with equally good or better effluent. (7) The value of glass tube filters as guides to plant operation is questionable.



Effect of porosity of sand on filter runs

Based on investigations and experiments at the Chicago Experimental Filtration Plant, the author finds that (7) is not so. That, for (5), 3.8 power should be substituted for the cube, indicating that angular materials give longer filter runs than rounded. When weak flocculation occurs, filtering materials giving long runs are more apt to permit passage of coagulated matter than those giving short ones, no matter what the filter material. Choice of filter material should be dictated not by isolated tests nor by general averages, but by consideration of effluent quality during the worst conditions under which the material may be called upon to operate. The selection of filtering materials should be governed primarily by their ability to safeguard the public health at all times, under the worst conditions; not by length or runs or other cost features.[A27]

A Radio Water Stage Recorder

After 3 years of experiments and tests, the Los Angeles County Flood Control Dist. has developed a device which automatically announces by radio once an hour (or other time interval) the height of water in distant streams, reservoirs, etc. A float revolves a drum carrying 100 longitudinal grooves, each having a depression indicating a gauge reading 0.1 ft. higher than the groove below; the groove on top at any instant corresponding to the float height. At the predetermined intervals a motor-driven trolley sends a contact along the top slot, and it sends a radio call corresponding to the depression therein. Transmitting antennas are of the semi-directional type. The transmitter is a simple 4-watt quartz oscillator, using power supplied by heavy-duty B batteries. The station is visited once a month to replace batteries and wind up the time clock.[E9]

Mains at Stream Crossings

In Indianapolis, Ind., the water mains cross streams or canal at 29 places, being laid in the stream bed at 17, and on bridges at 12. The latter, where 12″ and under in diameter, give trouble in zero weather if not insulated unless the velocity is maintained above ½ ft. per sec., and to maintain this

bleeders draining into the stream are provided, giving the equivalent of a 1″ stream and kept open while the temperature is near zero. Four methods of insulation are used—a box in which the pipe is surrounded with 4″ to 6″ of sawdust (must be kept dry); three 1″ layers of animal hair laminations with a covering of tarred felt paper; three layers of Johns-Manville standard corrugated asbestos insulation wrapped with an asphalt-saturated felt secured with jute yarn; and rock and cork steam line insulation, made 3″ thick in halves with the inner 2″ largely cork and the outer 1″ of rock-cork concrete, a ½″ space between pipe and insulation providing dead air insulation. None of the insulated mains have frozen, even when some under ground have.[E6]

Steel Facing for Dams

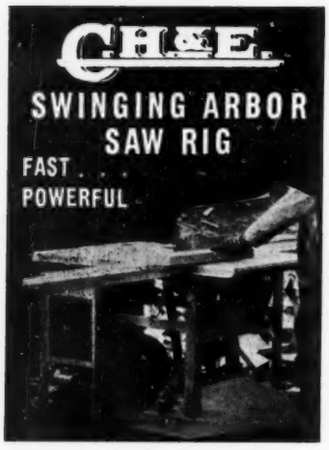
Steel plates were used as watertight face for a rock-fill dam in 1900, the water side covered with bituminous paint; still in good condition. Two Bainbridge type dams (steel plate inverted arches, suspended between steel bents) built in 1898 and 1901 are still in good condition. Used as facing on a gravity fill dam, with welded joints, it is absolutely watertight and amount of fill can be made 25 to 50% less than if core wall be substituted. Plates used are generally ¼″ to ½″ thick, about 100″ wide and 20′ to 30′ long, all plates in a tier ending in a common expansion joint at each end. Plates are lap-welded, permanent rivets being used 12″ centers 2″ from the edge for assembly and stiffening joint. Plates are assembled on horses about 2½ ft. from the embankment surface to permit assembling and painting, which space is later hand filled and tamped. The steel face is carried into a concrete cut-off wall at the bottom and ends, the expansion joints of the steel being continued into the concrete. Riveting and calking plates costs 22½% more than the above.[L1]

Canadian Filtration Practice

Canada has 1,268 water works systems, serving 5,646,692, which is 52% of the total population. Of these, 274 treat the water; 7 with filtration only, 123 with filtration and chlorination, 132 with chlorination only, 1 with filtration and ultra-violet rays, 2 with softening and iron removal, 5 with infiltration, and 4 miscellaneous. Data are given from 67 gravity filtration plants serving 2,430,000 people, and 47 pressure filters serving 323,000. Most of these use aluminum sulphate. One pressure and one gravity plant use ferric salts. Of the pressure filters, 8 have no mixing or settling facilities and in several others the amount of this is negligible. Sand of 0.45 mm is most common. All but one of the pressure filter plants chlorinate, 37 before filter, 6 after, 2 both. Of the gravity plants, 60% use solution feed, 40% dry feed; 27 mix in a baffled chamber, 10 with spiral flow, 8 "mechanical," 3 by pumping, 1 aero-mix. Sand used, 0.40 to 0.50 mm. Chlorination after filtering in 50 plants, before and after in 11, before only in 6. Taste and odor control are reported by 16 plants.[A29]

London, England, Water Laboratories

The Metropolitan Water Board of London, England, last autumn opened its new laboratories, divided into four main sections—chemical, bacteriological, biological, and administrative. Building is steel frame, brick walls; floors and roof of hollow tile, the latter with cork insulation against temperature. There are incubating rooms instead of incubating boxes. During 1937, 22,244 bacteriological samples were examined, 5,788 chemical samples, 7,834 taste samples, and 3,156 biological samples; a total of 38,922.[F9]



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Bibliography of Waterworks Literature

The articles in each magazine are numbered continuously throughout the year, beginning with our January issue.

c. Indicates construction article; *n*, note or short article; *p*, paper before a society (complete or abstract); *t*, technical article.

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16. Public Relations from Standpoint of a Municipality Owned Plant. By H. E. Wolbert. Pp. 1923-1925.
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18. Operating a Small Water Works Plant. By L. E. McQueen. Pp. 1929-1937.
19. The Arlington County (Virginia) Water System. By A. T. Lundberg. Pp. 1938-1945.
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21. Fire Protection and the Distribution System. By G. Tatnall. Pp. 1953-1963.
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23. An Unusual Standpipe Failure. By C. H. Bliven. Pp. 1971-1973.
24. New Emergency Repair Truck for Minneapolis. By J. A. Jensen. Pp. 1974-1977.
25. New Uniform System of Accounts. By A. L. Adams. Pp. 1978-1985.
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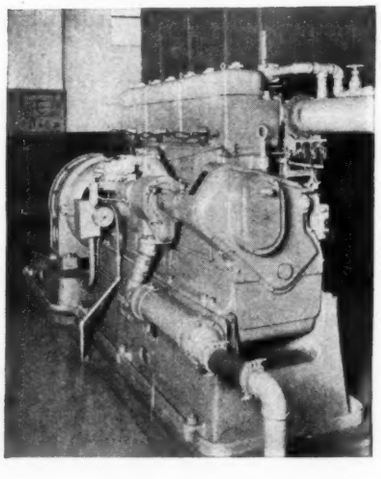

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A Digest of the Sewerage Literature of the Month giving the main features of all the important articles published

Sewage Treatment in the United States

In 1938, 4,667 communities in 47 states had treatment plants serving 40,884,800 people—52% of the urban population. As to population served, New York State leads with 5,539,000 —50% of the urban population; New Jersey treats the sewage of 78%; Pennsylvania that of 25%. In number of communities with treatment, Texas leads with 425, New Jersey has 263; New York, 256. By states, the sewage of more than 60% of the urban population is treated in Connecticut, New Jersey, Maryland, Georgia, Ohio, Illinois, Wisconsin, Michigan, Minnesota, South Dakota, Kansas, Oklahoma, Texas (95%), Colorado, New Mexico, Arizona and Oregon. Of the total plants, 44% have complete or oxidation treatment; 20% disinfect the effluents. There were 1,140 trickling filters, 223 activated sludge. Sludge digestion was used at 839 plants; sludge drying beds at 3,168 (223 of them covered); mechanical dewatering at 61; incineration at 29; fertilizer production at 156.[E7]

Ferric Salts and Non-Settleable Solids

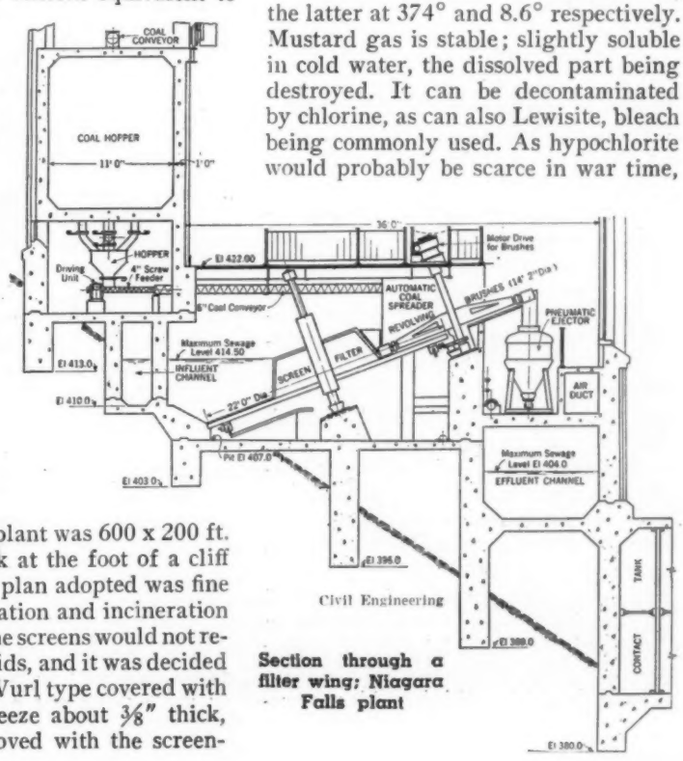
It is found that the demand for ferric coagulant in chemical precipitation is not correlated with the general strength of the sewage as measured by the suspended solids and BOD determinations, even when it is of strictly domestic origin. Also it has been found that the settleable solids do not influence to any appreciable extent the dose required for clarification, nor do any particles larger than colloidal size. The non-settleable solids are derived chiefly from feces and soaps, and the carbon-nitrogen ratio is about 2:1 as compared to the 9:1 of settleable solids; they make up about 1/3 of the BOD of domestic sewage. Experiments with non-settleable matters led to conclusions that no correlation exits between the amount of ferric salt necessary for clarification and the amount of non-settleable matter, or of colloidal matter, in sewage; that mere physical form of sewage matter was not responsible for coagulant absorption; that the presence of soaps, casein and feces in the non-settleable fraction of sewage are not involved; in fact, that the non-settleable solids present in domestic sewage account for little if any of the coagulant demand.[C3]

Recent Progress in Refuse Incineration

Among recent developments in incinerator progress are: Roanoke, Va., 200 tons per day. Greenwich, Conn., 150 tons. Newport, R. I., 100 tons. Schenectady, N. Y. (under construction), 210 tons. Rochester, N. Y., rubbish incinerator furnishes steam for garbage reduction. New Rochelle, N. Y., construction to start soon. Greece, N. Y., 15-ton multi-hearth for undigested sludge and ground garbage. Oxford, O., soon under construction. Cedar Rapids, Ia., recently contracted for. Winfield, Kans., 30 tons of refuse and sewage sludge. Cincinnati, O., 20 tons. Tenafly, N. J., 24 tons of sewage sludge. Brewster, N. Y., 15 tons. Martinesville, Va., 45 tons.[H11]

Screen Filters at Niagara Falls

Operation as performance test began in December, 1938, of the Niagara Falls, N. Y., treatment plant. Sewage averages 15 mgd of domestic sewage and 50 to 60 mgd industrial waste; suspended solids content equivalent to 650,000 population, actual population 75,000. Normal flow of river 190,000 cfs, with 105% dissolved oxygen and a BOD load requiring 21%, leaving 84% saturation to oxidize the sewage. Therefore removal of coarse suspended and floating materials and disinfection suffices. The only practicable site for the plant was 600 x 200 ft. on a sloping bank at the foot of a cliff 150 ft. high. The plan adopted was fine screening, chlorination and incineration of screenings. Fine screens would not remove sufficient solids, and it was decided to use a Riensch-Wurl type covered with a mat of coke breeze about 3/8" thick, continuously removed with the screenings and immediately replaced with fresh screenings from an overhead hopper. The combined coke and screenings are burned in a multiple-hearth incinerator. There are 6 screens 22 ft. diameter with 1/32 in. slots. During storm flow the coke is omitted and they act as screens only, taking up to 90 mgd, any excess of this being bypassed to the river. The sludge contains 15-20% solids. The plans provided for centrifugal dewatering but the plant is being operated without this. The effluent is discharged into 6 chlorine contact tanks, where it can receive up to 6,000 lbs. of chlorine per day. All the plant is enclosed in a building which is ventilated by exhaust fans, 90,000 cu. ft. per min. capacity, which drive the air into an annular space between the chimney and a surrounding tower 175 ft. high. Total cost of plant, $1,400,000.[L2]



Civil Engineering

Section through a filter wing; Niagara Falls plant

War Gases and Sewage Plants

Of the war gases, probably the only ones that would affect sewage plants are the blister gases—mustard gas and Lewisite. They are not really gases but are heavy oily liquids. The former boils at 423° F. and freezes at 58° F., the latter at 374° and 8.6° respectively. Mustard gas is stable; slightly soluble in cold water, the dissolved part being destroyed. It can be decontaminated by chlorine, as can also Lewisite, bleach being commonly used. As hypochlorite would probably be scarce in war time,

the authors suggested providing electrolytic sterilizing equipment, using salt and electricity for obtaining the chlorine. Discharged into salt water, the chlorine therein would probably decontaminate it. It is desirable to have a lagoon or spare tank into which contaminated sewage could be bypassed for gradual treatment, and to prevent damage to bacterial life where this is used. Where the sewage has a pH of 8 or higher, the alkali content would probably neutralize the gases. If bleach is not available, lime is the next best material for decontamination. Contaminated sewage can in some cases be turned onto land, but nothing is known concerning its effect on soil bacteria. Owing to its corrosive action, the gas might seriously affect machinery, which can be prevented by having rubber covers for all units. Gas would be removed with sludge, and would continue to be a danger until the sludge is decomposed. It is desirable to provide a gas-proof room from which all equipment can be operated by remote control; also "decontamination" clothing for all key men at the plant.[D6 & 8]

Vacuum Filtration of Sludge

Vacuum filters made by reputable companies will perform successfully and with little mechanical regulation if the sludge is properly conditioned—by far the most important step in sludge filtration. Suggestions for improvement of installations include: 1—Locating filter exhausts so as to avoid nuisance from noise and odors; odors are worst from raw sludge, less from digested sludge, negligible from elutriated digested. Exhausting into sewer manhole, pump well, through muffler to above the roof. Filter room exhaust fans are generally desirable. 2—Feed lines from conditioning tanks to filters should be at least 6″ diameter. 3—Filter vat drains, at least 4″ diameter, should not empty into sludge conditioning tanks. 4—Vacuum pumps, especially the dry-vacuum type, should be protected against entrance of filtrate. The best arrangement is a 30′ to 32′ barometric leg, generally requiring an elevated vacuum tank, aided by placing vacuum pumps in a basement; which, with air compressors and filtrate pumps similarly located, gives less noise on the operating floor. 5—Pumps or bucket elevators for handling sludge to or from conditioning tanks should have a wide range of capacity. For feeding conditioned sludge, gravity is greatly preferred; pumps if used should be plunger type, controlled by float in sludge vat. 6—Valves on sludge piping should be full-opening type, not plug valves. 7—Cake conveyor belts should have higher sides to prevent spilling. Excessive slope causes cake to roll into balls. 8—More attention to safety—space around filter, nonslip treads and handrails, ample lighting.

For filter cloth, unbleached cotton probably best. Keep cloths wet to prevent mildew and drying out of decks beneath; wash thoroughly after filtering; when greasy, wash with a mild soap. When lime is used for conditioning, wash occasionally with diluted hydrochloric acid or "Hibitite."

Septic raw sludge is difficult or impossible to condition properly. If the sewage is septic, raw sludge should not be filtered. Desirable solids content is: for raw sludge, 6 to 8%; digested sludge, 14.5 to 17.5%, if 20% or above it must be diluted. Elutriation facilitates filtering stale raw or partially digested sludge, eliminates lime as a conditioner and ammonia odor. Using ferric chloride floc alone, the sludge is unstable and should be filtered immediately.

Concentration tanks are desirable, preferably deep cylindrical. In batch-mix plants, conditioning tanks can be used for concentrating. In batch-mix plants, conditioned raw sludge should not be held more than 1.5 hrs.; digested sludge, 5 hrs. For mixing, mechanical agitation is preferable to compressed air. The tendency is to mix too long; for ferric chloride, 5 to 8 min. is generally ample, 2 to 3 min. may be; for lime, 5 to 10 min. There is an optimum dose; an excess may not only cost more, but give poorer result and damage filter cloth.[C5]

Air Diffusion and Surface Aeration

In activated sludge treatment, there are some cases where one of these is preferable, others where the other is. Proponents of both admit this. There are about 200 plants using diffused air, 100 using mechanical aeration, and 20 a combination of the two. The most suitable unit of measurement for comparing operating cost of plants is the kwh used per pound of BOD removed by the aerators. F. C. Roe (representing air diffusion) estimates that air diffusion uses more current per pound of BOD than does mechanical for plants of less than 7 mgd—apparently more favorable to the latter than its representative—S. E. Kappe—claims; but data are obtainable from only a few plants. Apparently less power units are required for high-strength sewages than for low. The longer detention period required by mechanical offsets the lower rate of power consumption. In mechanical aeration, greater flexibility in power economy is possible; at times it may be possible to take one or more units out of service, but the compressor for air diffusion must be operated at low efficiency during low demands. Most manufacturers offer a minimum power consumption of 0.35 kwh per pound of 5-day BOD removed. In the matter of plant cost, Roe estimates that for mechanical plants is lower up to 0.7 mgd capacity, higher for larger plants. Kappe places the size of equal cost at 1 to 1.5 mgd. The mechanical requires larger tank capacity but the mechanical equipment cost less. Combining plant and operating cost, Roe estimates that for a 0.2 mgd plant, diffused air costs more than twice mechanical aeration; at 1.0 mgd the cost is about the same; at higher rates, mechanical costs several times as much as air diffusion. Digester gas installation is considerably less expensive for blowers than for generator-motor type. Effective operation is possible with both; but "where appreciable trade wastes are encountered, it appears that air diffusion will generally effect greater BOD reduction than mechanical aeration" (Roe). (In this discussion, circulating pumping devices only are considered, not revolving paddles.) For mechanical aeration, tanks of not over 50,000 gal. capacity are desirable. The sewage level in the tanks should not vary more than 1 or 2 inches. One company bases its design on supplying 6 ppm of oxygen to the sewage at each turnover, and a minimum of 3 turnovers an hour. Velocity of sewage at the bottom of a tank should not be less than 0.5 to 1.0 ft. per second.[C9 & 10]

Pond Oxidation of Tank Effluent

Since 1933, Texas A. & M. College has been discharging sewage tank effluent, now amounting to 500,000 gpd. into a 14-acre lake for oxidation. (See "Digestion Tank" in PUBLIC WORKS for December, 1936.) Dr. Imhoff questioned the statement that the lake supplied 50 lb. of oxygen per acre per day, suggesting that organic matter settling to the bottom took some BOD with it which would make itself felt later. However, after 3 summers, no evidence of this has appeared. Part of the oxygen is due to surface absorption, and with the high temperature of Texas this is probably greater than in Germany or the northern part of the United States. Some oxygen (how much is not known) also is undoubtedly furnished by the algae and other vegetable growth in the lake. This subject is being investigated by the Texas A. & M. College sanitary engineers. The sewage entering the college lake had a BOD of about 370 ppm. Another Texas lake whose influent had a BOD of 14.5 was found to be supplying about 35 pounds of oxygen per acre.

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for irrigation, a 12-acre lake acting as a balancing reservoir. There is a prolific growth of algae in this lake; and (possibly because of this) no B-coli in its effluent. The same is found true at the A. & M. College lake.[X5]

Digestion at Rahway Valley Plant

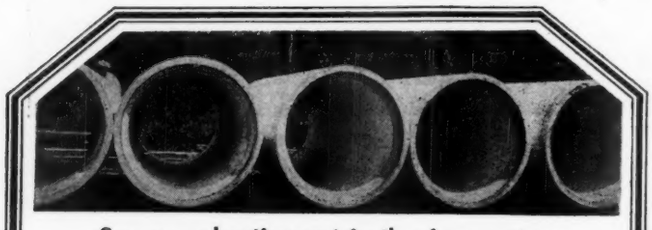
This plant treats sewage from 60,000 population in nine municipalities. Has been in service since June 1937. Digestion tanks are Dorr 2-stage system, provide 2.5 cu. ft. per capita for present population. Sludge is pumped by a 160 gpm plunger pump and a 300 gpm horizontal centrifugal; the latter "entirely unsatisfactory for the service imposed." Sludge is air dried, 2/3 of the area open, 1/3 covered; the former more efficient in summer, the latter slightly more so in the fall; both freeze in the winter. Screw conveyor in the grit collector sometimes freezes. Supernatant can be disposed of only into settling tank influent; when high in solids it tends to overload the digestion tank, seed the settling tanks with oxygen depleting and sulphide producing organisms, and requires increased chlorination. Chlorine is applied only ahead of the settling tanks, sufficient to give a residual in the plant effluent, requiring a dose of 10 ppm or slightly less. Digester content is kept at pH 7.2 by adding milk of lime; "Kemikal" lime more satisfactory than common masons' lime. Total solids in raw sludge 5.2%, primary digestion tank 3.2%, secondary tank, 5.7%. Gas production, 0.96 to 1.27 cu. ft. per capita per day, 8.7 to 9.1 cu. ft. per pound of volatile solids added; average 53.8% methane, 31.7% CO_2, 7.4% nitrogen, 6.1% hydrogen, 1.0% oxygen. Average heat value, 590 B.t.u.[G5]

Pasadena Sells Sludge as Fertilizer

Activated sludge from Pasadena, Calif., plant was at first dewatered slightly and spread on city-owned orange groves with manure spreaders. Because of the nuisance, this was changed to impounding in beds, also a nuisance. In 1924 two vacuum filters were installed, and filter cake buried in ditches. This also was not satisfactory, and mechanical drying was begun in 1926. Using alum as a coagulant, 8 to 10 lb. per 1,000 gal. of liquid sludge gave a cake with 83 to 85% moisture (82 to 83% desirable). Adding 10 lbs. of diatomaceous earth gave a moisture content of 79 to 80%, doubling the dryer output, and the additional fertilizer brought more than the cost of the earth. Change from alum to ferric chloride was made in 1930 and "filter aid" (earth) was no longer necessary. Now the sludge cake is dried to about 5% moisture, pulverized and screened, packed in 100 lb. bags and sold as "Nitroganic," with a guarantee of 6.00% nitrogen (actual average 6.65%) 3.0% phosphoric acid and 0.3% potash. In the fiscal year 1937-38, 3,492 tons of fertilizer were produced at a cost of $76,670 (including sales cost), brought in a revenue of $62,730, giving a net cost of sludge disposal of $13,940, as compared to $54,304 when the filtered sludge was buried.[C4]

Sludge Gas at Battle Creek

Battle Creek, Mich., collects about 1.5 cu. ft. of gas per day per capita, averaging 32.4% CO_2, 0.1% oxygen, 0.3% illuminants and 64.9% methane, giving a gross B.t.u. of 692.4. Of the 27,000,000 cu. ft. produced since Sept. 15, 1936, 5,100,000 was used by the engine, 6,700,000 by the boiler, and 14,800,000 burned to the atmosphere. Calling B.t.u. value 550, assuming overall efficiency of 33% and taking the average cost of electric power at the plant, the gas produced could have generated current worth $14,358, of which $8,084 worth was burned to waste.[H13]



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Bibliography of Sewerage Literature

The articles in each magazine are numbered continuously throughout the year, beginning with our January issue.

c. Indicates construction article; *n,* note or short article; *p,* paper before a society (complete or abstract); *t,* technical article.

C *Sewage Works Journal*
November

1. Biologic Oxidation Determination. By D. E. Bloodgood. Pp. 927-935.
2. A Study of Trickling Filter Loadings. By O. J. Knechtges. Pp. 936-938.
3. *t.* Effect of Non-Settleable Solids on the Coagulant Demand. By H. W. Gehm. Pp. 939-944.
4. Conditioning and Sale of Sludge for Fertilizer. By W. A. Allen. Pp. 945-948.
5. Vacuum Filtration of Sludge. By L. W. Van Kleeck. Pp. 949-974.
6. Results of First Nine Months' Operation at Neenah-Menasha, Wis. By J. M. Holderby. Pp. 975-979.
7. Legal Aspects of Sewer Rental Laws and Connections from Outside to City Sewer Systems. By H. Buckley. Pp. 980-987.
8. Administration of New York State Requirements Relative to Qualifications of Sewage Treatment Plant Operators. By A. F. Dappert. Pp. 988-998.
9. Activated Sludge: The Case for Air Diffusion. By F. C. Roe. Pp. 999-1006.
10. Resume of Operating Experience of Mechanical Surface Aeration. By S. E. Kappe. Pp. 1007-1016.
11. Use of Hydrated Lime in the Activated Sludge Process. By T. R. Haseltine. Pp. 1017-1042.
12. Phenolic Waste Treatment Plant of the Dow Chemical Co. By I. F. Harlow, T. J. Powers and R. B. Ehlers. Pp. 1043-1059.
13. Starting a New Sewage Plant. By F. W. Jones. Pp. 1060-1064.
14. Operation of Intermittent Sand Filters. By W. H. Wisely. Pp. 1065-1066.
15. First Year's Operation of Elizabeth, N. J., Sewage Treatment Plant Serving 12 Municipalities in Essex and Union Counties. By L. E. West. Pp. 1067-1075.
16. Annual Report, Worcester, Mass., Treatment Works. By J. H. Brooks, Jr. Pp. 1075-1082.
17. Chicago Program Nears Completion. By F. W. Mohlman. Pp. 1083-1084.

D *The Surveyor*
December 30

5. Designing Surface Water Sewers Without "Trial and Error." By L. B. Escritt. Pp. 763-765.

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6. *p.* Air Raid Precautions Adaptable to Sewage Disposal Works. By F. J. R. Batten. Pp. 13-14.
7. *p.* Electricity as Applied to Sewage Purification. By C. V. Hill. P. 25.

January 13

8. *p.* Discussion of D 6. Pp. 41-43.

E *Engineering News-Record*
December 29

4. *p.* Irrigation with Sewage. (Kingsville, Tex.) P. 821.

January 5

5. Baltimore Modernizes Its Sewage Plant. By E. J. Cleary. Pp. 33-35.
6. Notes on Sewage Disposal. By W. Rudolfs. P. 39.

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7. Inventory of Sewage Disposal Facilities. Pp. 60-61.

G *Water Works & Sewerage*
January

5. Rahway Valley Sewage Treatment Plant. By N. C. Wittwer. Pp. 13-20.
6. Hazards at Sewage Treatment Plants. By L. Luther. Pp. 32-34.
7. Sewerage Financing. By W. F. Tempest. Pp. 37-39.

H *Municipal Sanitation*
January

5. Chicago Treatment Program Moves Toward Completion. Pp. 19-21.
6. $2,000,000 Improvements at Baltimore Back River Works. By C. E. Keefer. Pp. 22-25.
7. Gas Explosion at Dayton Sewage Plant. Pp. 25, 71.
8. Atlanta, Ga., Builds Modern Disposal Plants. By L. G. Pearce. Pp. 27-28.
9. Digestion-Elutriation Feature Hartford Metropolitan Plant. By W. A. D. Wurts. 1 p. 29-31.
10. Detroit Primary Treatment Plant Nears Completion. By A. B. Morrill. Pp. 32-37.
11. Incineration Gains in Popularity. Pp. 35-36.
12. Sanitation Progress Review. Pp. 37-43.
13. Gas Production and Utilization at Battle Creek Sewage Works. P. 43.
14. Maintenance of Activated Sludge Aeration. By L. M. Johnson. Pp. 45-47.

L *Civil Engineering*
January

2. New Sewage Treatment Works at Niagara Falls. By P. B. Streander. Pp. 13-16.

M *Canadian Engineer*
January 10

1. *p.* The Organization of Stream Pollution Surveys. By J. S. Hoskins. Pp. 8-10.

P *Public Works*
January

6. Experiments on Treatment of Cannery Wastes. Pp. 10-11, 49.
7. Gas Explosion at the Dayton, O., Sewage Plant. Pp. 18, 36.
8. Water Course Pollution by Sewage. P. 48.

X *Proceedings, Texas Water Works Short School Year of 1938*

1. Stream Pollution and Its Consequences. By J. K. Hoskins. Pp. 77-83.
2. Progress and Possibilities in Sewage Treatment Research. By J. K. Hoskins. Pa. 89-97.
3. Problems of the Operator of the Small Sewage Treatment Plant. By J. C. Oliver. Pp. 100-111.
4. Irrigation as a Means of Sewage Disposal (at Kerrville, Tex.). By A. P. Hancock. P. 112.
5. Kingsville Sewage Treatment (by Irrigation). By R. L. Peurifoy. Pp. 113-118.
6. Treatment of Milk Waste. By O. T. Turner Pp. 123-125.
7. Municipal Sanitary Status in Texas. Pp. 127-143.

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Special features incorporated in new Warco "Whizzard" variable weight roller are: a wide range of rolling speeds; ease of moving from job to job under its own power at speeds up to 35 m.p.h.; quick change from rolling work to roading; short turning radius and variable weight. The visibility afforded the operator in working along curbs and gutters makes this a machine excellent for ordinary roller work in city streets, parks, playgrounds, cemeteries, and for general patch work any place.

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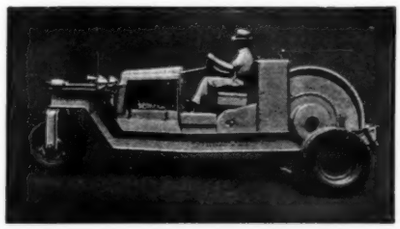

Warco "Whizzard" Roller

4½ minutes. For rolling hot stuff the makers have developed a steel roll to replace the rubber tires in front. They have so designed the hood and cowl as to make the motor and transmission more accessible for servicing than most trucks.

Information bulletins with complete specifications are available from W. A. Riddell Corp., Bucyrus, O.

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The tamping feet are not the conventional straight shaft shape, but are tapered; a special design that permits stronger base construction and makes it more difficult for the feet to become clogged. Because of the shape, they enter the new fill material easily, give maximum compaction, and pull out of the ground without kicking or tearing up the newly rolled material. These feet are 8 inches in length.

Le Tourneau flexible sheepsfoot roller

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The new Hough traction driven road sweeper is equipped with a 7′ brush, 30″ in diameter. The brush is adjusable as to ground pressure and to the crown of the road. The power for driving the brush is taken from the left rear wheel and transmitted to the brush through a three speed standard automotive transmission which runs in oil and is fully enclosed in a dust proof case. The brush may be operated in either of the three speeds by merely shifting the gear lever into the proper position. The machine is equipped with a tow pole easily hitched to either a truck or tractor.

A catalog will be furnished on request to the manufacturer, The Frank G. Hough Co., 919 North Michigan Avenue, Chicago, Illinois.

12th National Asphalt Conference

The 12th National Asphalt Conference will be held at the Biltmore Hotel, Los Angeles, Calif., during the week of Feb. 27. A most interesting and instructive program has been planned, which is too long to treat adequately here. Detail programs are available from the Asphalt Institute, which has offices in New York, Cincinnati, Kansas City, Mo., Dallas, Tex., and San Francisco, Calif.

U. S. Civil Service Examinations

Applications will be received by the U. S. Civil Service Commission until Feb. 21 east of the Rockies and Feb. 24 in the mountain and western states, for five grades of topographic draftsmen, paying from $1,620 to $2,600 per year. Examinations will be held in most of the large cities. Fuller information from Secretary, Board of Civil Service Examiners, at any first class postoffice, or from U. S. Civil Service Commission, Washington, D. C.

Ohio, Pennsylvania and Michigan manufacturers of clay sewer pipe have organized The Clay Sewer Pipe Association, Inc., with offices in the Oliver Building, Pittsburgh, Pa., and as rapidly as possible other offices will be opened in various cities in the East. Promotional effort wil be under the direction of H. C. Maurer of Akron, Ohio, for many years connected with the sewer pipe industry in a sales capacit .

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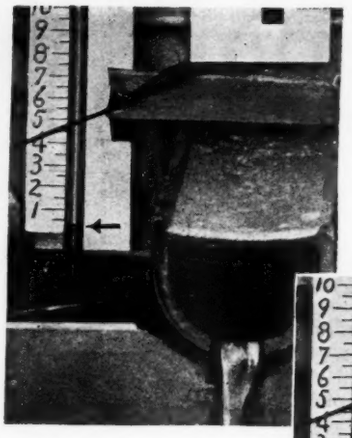
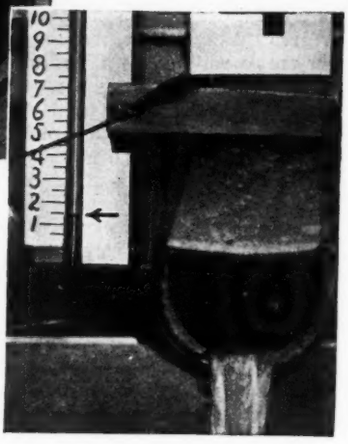
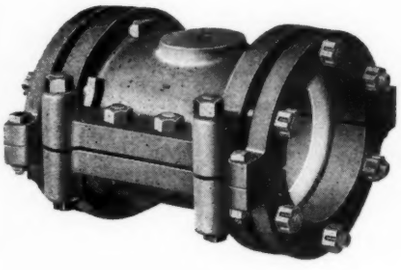


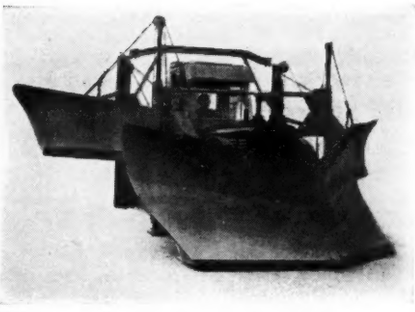
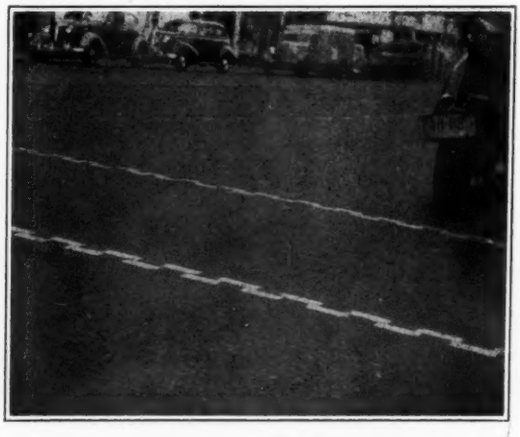
Skip-Pipe is a radically new design of clay subdrainage pipe. The illustrations show the general appearance. Sizes are 5 to 12 inches.



Catalog UD-2 issued by Robinson Clay Products Co., Akron, O., gives complete data, with results of tests. Sent on request.



Clow-National split sleeve for making pipe repairs. Can be installed in a wet trench or even under water, 4 inch through 12 inch. Catalog on request. James B. Clow and Sons, Chicago, Ill.

Right, Bucyrus - Erie makes equipment so that by changing only the blade and frame, a bulldozer becomes a snow plow.

Below, Armor-Flex Co., St. Louis, Mo., make these highly visible, long lasting traffic markers. Full data on request.